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THE LAW OF STORMS DEVELOPED.

By PROFESSOR THOMPSON B. MAURY,

OF THE SIGNAL-OFFICE, WASHINGTON.

METEOROLOGISTS tell us that their science is as old as Aristotle. If we should judge by its progress up to the middle of the present century, its antiquity furnishes little to boast of; for, in the long lapse of centuries, it must have proved an incorrigibly dull scholar. Within the past few years, however, it has greatly improved, and, especially since it became identified with the popular and important systems of storm-warnings and weather-forecasts, it has been rapidly developed. This is peculiarly the case in America, and it is not wonderful, when we consider the comprehensive observations of our meteorological bureau, and the many beautiful phenomena which its publications disclose.

If Vasco Nunez, the discoverer of the great South Sea, was so awed by the grandeur and expanse of its waters, as seen with the naked eye, how much more may we be impressed as telegraphic meteorology enables us to discover, at a glance, the tossings and undulations of the aërial ocean over the larger part of the hemisphere!

It is to some of the deductions, that may be justly made from the extensive and synchronous observations of the modern weather-systems, as they bear upon those weather-problems, which, from time immemorial, have interested mankind, that we now ask attention.

Until the year 1821, "the law of storms," simple as it is, was unknown to the most profound meteorologists and expert seamen of the world. It was then first discovered and announced by Mr. William C. Redfield, of New York, and established by the labors of that great mind, against the constant perversions and opposition of the scientific empirics of his day. It can be easily comprehended in its great

outlines, and as far as our present purposes require. It assumes nothing, supposes nothing; but, from thousands of actual and actually recorded observations, presents the phenomena of spiral currents of air seeking a common centre of depression, and, in the attempt to find that centre, acquiring a vorticose or rotatory motion. The direction of this rotation Mr. Redfield found to be uniformly, in our hemisphere, contrary to that of the hands of a watch, with its face turned upward; and, in the Southern Hemisphere, the rotation is with those hands, or with the sun in its diurnal round. It is easy to see that, if the atmospheric column, resting over any given area of the earth's surface, should, for any cause, be suddenly diminished, or its pressure and intensity be reduced, the gaseous fluid would rush in from all surrounding regions to restore the disturbed equilibrium; and, if the earth was not whirling around on its axis, every particle of the centre-seeking air would endeavor to move on the shortest, or the straight line. It is known, from the principles of mechanics, that this endeavor can never strictly be executed, because the axial rotation of the globe incessantly so acts as to throw every body, while in motion, in our hemisphere, to the *right* of the line on which it is moving, no matter whether that line be from east to west, north to south, or at any conceivable angle with the meridians or the equator. Obeying, in part, this tangential impulse, every particle of wind must take up a resultant motion. If it begins to blow toward the depressed centre of the storm as a north wind, it trends to the west, and is felt as a northeaster; if it begins as a south wind, it diverges as a southwester; if as an east wind, it becomes a southeaster; and, if as a west wind, it soon changes into the boreal northwest wind.

It has often been asked whether the storms of our latitudes attain the immense size formerly attributed to them; and many eminent writers have denied the possibility of their reaching a diameter of more than two or three hundred miles. Mr. J. K. Laughton, in his recently-published "Physical Geography," would have us believe that cyclones "do not attain the enormous magnitudes which have been assigned them." But this opinion rests merely upon conjecture, not yet upon a correct physical theory.

It is a well-known fact that the monsoons generated on the central plateau north of the Himalaya Mountains, and the whole system of Asiatic wet monsoons, may be regarded as an immense and prolonged cyclone; and extend their "backing" influence into the Indian Ocean, and reach far to the south, through more than forty degrees of latitude (a radius of 2,500 geographical miles), and from the 60th to the 140th meridian of east longitude, far out into the Pacific, beyond the Bonin and Ladrone Islands, southeast of Japan. The whole system of wet monsoons may also be justly regarded as a grand cyclone, whose centre is stationary over the heated plains of Central Asia,

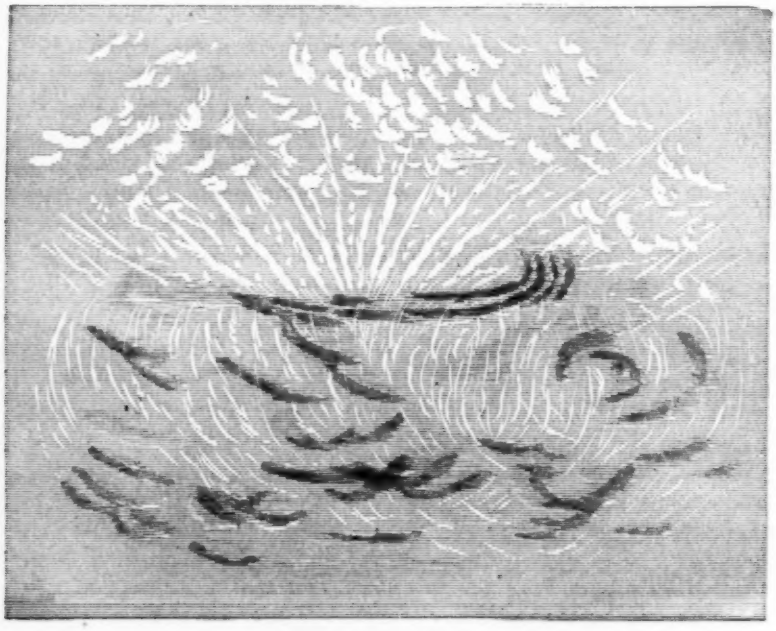
whose intro-moving winds, bearing the evaporations of the Asiatic seas and oceans, feed it with meteoric fuel for six months in the year, and whose periphery may be regarded as embracing nearly one-third of the entire Eastern Hemisphere. Analogy, therefore, warrants the idea of a great cyclone. But, apart from all this, actual observations in different parts of the globe prove the frequency of storms of enormous magnitude. Thus, in the celebrated Gulf-Stream storm of 1839, as Sir David Brewster long ago pointed out, several stanch merchantmen were foundering off the coast of Georgia, near Savannah, in the very heart of the gale, at the same hour that the winds in its northwest quadrant were taking the roofs off houses in New York and Boston, more than 800 miles distant—clearly revealing a cyclone whose formation was symmetrical, and whose diameter must have been nearly 1,300 miles. But, not to go back to old data, the West-Indian storm of the 18th of August, 1871, before its centre had moved north of Florida, had begun to draw upon the regions of high barometer in the northern States, had exerted its influence as far north as New London, Connecticut, and gave us the northeasterly cyclonic winds in the northwest quadrant of the whirl, on the entire Atlantic coast. The more furious cyclone of the 24th of August, discovered to be then southeast of Florida, and telegraphically foreannounced as likely to endanger the coasts of the Southern States in less than forty-eight hours, appeared on the 26th in full force in Northern Florida, but not until some eight or ten hours after it had set the atmosphere all around it (as far north as Boston) in cyclonic motion, and had caused the storm-cloud to spread itself over the entire region of the United States on the eastern slopes of the Alleghanies, and as far westward as Knoxville, Tennessee. It is no uncommon thing, as Redfield, Espy, Henry, Loomis, and others, long ago showed, for an area of depression on the upper lakes to make itself simultaneously felt as far south as the Gulf of Mexico, and as far east as New England.

If it fell within the scope of the present design in this paper to consider the final cause of storms, it would be easy to show that, unless the law of storms ordained a large area, and a far extended path for the meteor, in some degree commensurate with the area of our immense continent, the meteor could not fulfil its office in the terrestrial economy—an office which, apparently, imposes upon it the task of gathering to its centre, through the agency of its intro-moving winds, the idle and inappreciable moisture scattered over the surface of the earth, condensing it into rain and snow, and diffusing it, in these forms, over immense districts of country.

It is of incalculable importance to observe, and carefully digest the fact, that, when a storm-centre or area of low barometer is once formed, it is the *nucleus* for a vast aggregation and marshalling of meteoric forces. No matter how small at first, under favorable atmospheric conditions, the *courant ascendant* is formed, condensa-

tion aloft sets in, and the precipitation only serves to add "fuel to the flames" of the cyclonic engine. This process widens in geographical area, and, after a few hours have elapsed, the storm may so develop as to cover a continent with its portentous canopy of cloud, while simultaneously strewing an ocean with wrecks, and throwing out, in the upper sky, more than a thousand miles in its front, the fine filaments of the premonitory cirrus and cirronus.

FIG. 1.

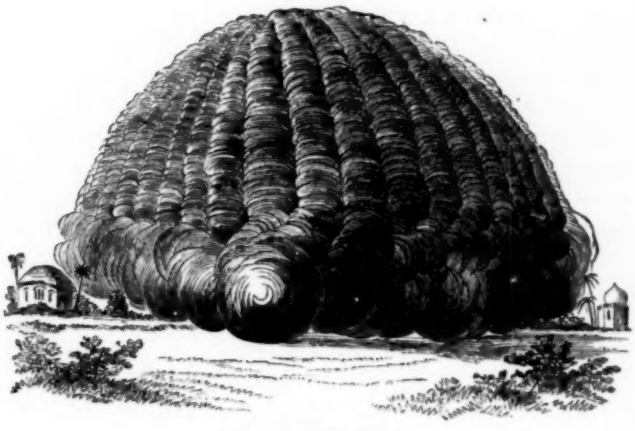


CIRRUS-CIRRONUS CLOUDS.

In close connection with the size and magnitude of cyclones must be considered the distance over which they pass from their initial point. Much has been said on this part of our subject, and not a few writers have accepted the doctrine of Admiral Fitzroy that they progress over but comparatively short distances. For such a view, however, it is impossible to find, either in the nature or physical office of the cyclone, any support whatever. The storm once engendered, no matter in what part of the world, may be stationary or progressive. There are well-authenticated instances of almost stationary cyclones and almost stationary typhoons, of which latter will be remembered the famous gale of the ship Charles Heddle — an Indiaman, carried round and round the storm-centre for five days — which progressed not more than ninety miles a day. Indeed, we may, as has been said, regard every wet-monsoon region as a stationary and semi-perennial cyclone.

Such a meteor has been shown to resemble an eddy moving in the current of a rapid river. The latter may be large or small, while it does not determine, but is determined by, the course of the on-flowing stream. It is true the centre of an eddy or water-hollow may soon be filled up and the whirl disappear; but it is because the depression is not maintained. If the depression could be maintained, it is easy to see that the eddy would continue, and pursue its way, as long as the current in which it is embodied continues to flow: it might be through the length of an Amazon or a Mississippi River. In the case of a cyclonic eddy or whirl, we know the atmospheric depression is maintained as long as the centre moves in a region sufficiently supplied with aqueous vapor to feed it. It is a physical impossibility, as has been often shown, that any storm, however vast or however violent, can prolong its advance or sustain its fury over a dry and desiccated surface. The most extended typhoons of the East, upon entering the dry and rainless continental regions, dwindle into the well-known and diminutive dust-whirlwind, such as Sir S. W. Baker describes as witnessed in Nubia, and as here illustrated. The Sahara is a more formidable barrier to the

FIG. 2.



THE DUST WHIRLWIND.

passage of a storm than the majestic mountain-wall of the Alps, and the simoom is, notwithstanding the stories of travellers and the legend of swallowing up of the army of Cambyses on the African desert, a wasted and worn-out cyclone. In his "Desert World," Mangin, compiling the more accurate observations of the phenomenon says: "It never prevails over any considerable area, and beyond its limits the atmosphere remains serene and calm; the phenomenon is of brief duration, the atmospheric equilibrium is speedily restored; the heavens recover their serenity; the atmosphere grows clear, and the sand-columns, falling in upon themselves, form a number of little hills or cones,

apparently constructed with great care, like those mimic edifices of sand made by children in their pastimes." The same writer also mentions a severe simoom which was "over in a couple of hours."

Embedded in the great aërial currents, however, and supplied with abundance of moisture, there is nothing to arrest either the rotatory or progressive movements of the storm. Like the drift-bottles cast upon the current of the ocean, and found after months to have been carried thousands of miles, from the equatorial to the polar parallels, there is every reason to suppose the tropic-cradled gale, and the minor storms also, are borne in the great atmospheric currents through quite as great distances. There is an authentic and well-attested account of a Japanese junk, lost or deserted off Osaka, drifting through the immense arc of the Kuro Siwo's recurvation, and encountered (in latitude 37°, by the brig Forrester, March 24, 1815) off the coast of California. That tiny craft must have followed in the bands of westerly winds and warm waters for seventeen months. Why, upon theoretical grounds, should we reject the hypothesis which represents the movement of storm-areas as prolonged for many thousands of leagues, or indeed that which represents them perpetually in motion around given centres of cyclonic or anti-cyclonic areas, keeping pace with the great winds in their eternal circuit?

As a striking corroboration of all this we find — what might have been assumed on theoretical grounds—that the logs and special observations of the Cunard steamships show that a vessel bound from Liverpool westward encounters frequent advancing areas of low pressure, indicating a number of rapidly-succeeding barometric hollows or depressions, "each with its own cyclonic wind-system, moving across the Atlantic as eddies chasing each other down a river-current."

The word *cyclone* has frequently, but incorrectly, been used as significant of an enormous or very violent meteor, as if its application was to be confined to the devastating hurricane of the West Indies or the terrific typhoon of the China seas. It simply means a storm which acts in a circular direction, and whose winds converge, by radials or sinuous spirals, toward a centre, moving in our hemisphere in the opposite direction to that of the hands of a clock, and in the Southern Hemisphere in a contrary direction. Taking this as the definition of a cyclone, it seems clear, from observation alone, that all storms are to be regarded as cyclonic. Volumes have been written to prove that this is not the case. But we have only to examine a few series of weather-maps from week to week to see that, wherever you have an area of low barometer, into its central hollow the exterior atmosphere from all sides will pour, and that in so doing a rotatory spiral or vorticose storm is generated. The tornado, the simooms, the dust-whirlwind, the fire-storm, even the slow and sluggish storm which moves

on our Western plains as the laboring wheel of the steamship buried in a heavy sea, all attest that a body cannot move on the earth's surface in a straight line. It is not more true with us that the Gulf Stream turns to the eastward, the Polar Stream to the westward, and the equatorial currents to the northward, than that every air-current, in obedience to the same law, should turn to the *right* of the line along which from any cause it is called to move. The meteorist has therefore only to ascertain by observation where the barometer is lowest, to know at once the direction of the winds from the circumjacent districts, far and near, or at least to test the mathematical law by a grand experiment.

The tangential and centripetal forces, acting at the same time on any particle of air in the storm, may be equal or very unequal, and the cyclonic character of the gale may be well marked or partly concealed. In the tornado, with a diameter of only a few hundred feet, the tangential force may not be appreciable to an observer, but it is present, and intensely assists in communicating vorticose motion to the storm, whose roar is heard with awe by the stoutest heart, as it crashes through the forest and even ploughs up the soil of the earth. If the cyclonic or spiral feature should fail to manifest itself in any storm, we ought to look for such failure in the tornado. It is true that no barometric readings have ever been taken in the narrow heart of a tornado, but abundant evidence exists of the fearful rarefaction in the centre. While the meteor, once set in motion, may move forward with great velocity and destructiveness, the danger is clearly due to the intro-rushing and gyratory winds. There is not an instance, it is believed, recorded in which a tornado moved as much as 100 miles an hour; probably one-half that velocity would be too high an estimate for its usual and ordinary motion. But the wind, moving straightforward at the rate of 60 or 80 miles an hour, never worked any thing like the disaster of a tornado. In the West-Indian hurricane, blowing at the rate of 100 miles an hour, houses have been blown down, ships innumerable stranded; but all this is mere child's-play compared to the suction and whirl of the tornado. The conclusion forced upon us is, that the ravages of the latter are due, not to the weight of the atmosphere, moving as a river-torrent in a straight line, nor to the rush of air behind the travelling vacuum, but to the torsive, racking motion—imparted to every object in its path—due to its gyration. To prove that this gyration is *always* from right to left, or against the hands of a watch, is, of course, practically impossible; but such a direction has often been observed in tornadoes.

It may, therefore, be safely concluded that, for all processes of meteorologic calculation, the disturbance, if not such at first, will soon become cyclonic. All daily weather-charts demonstrate this, not by a laboratory or lecture-room experiment, but on an infinitely wider and grander scale, and in a manner far more conclusive than any merely

manual experiment could possibly make to appear. As one has happily said, "Nature makes no distinction between small and great; the drop of mist that lights gently down on a delicate flower, and the avalanche that sweeps away a village, fall in obedience to one universal law."

It has been asserted lately that the Gulf Stream has no influence upon storms; that they have no tendency to run toward it or to run upon it; and that what geographers and seamen have always said about the Gulf Stream as a "weather-breeder" and "storm-king" is absurd. I think it can be demonstrated that this well-known popular belief is not absurd.

It is an observation, as old as Aristotle, that the storms of the middle latitudes in the Northern Hemisphere advance from west to east. This is obviously partly due to the fact that the winds on their eastern sides are southerly, that they come from the equatorial regions, and hence are highly charged with aqueous vapor. This vapor is absolutely essential to the sustenance of the storm. Moreover, the law of storms requires that the southerly winds should enter the storm-vortex on the eastern side, and as this is the side on which the greatest quantity of vapor is found, and the side of greatest condensation, of the greatest evolution of latent heat, hence of the greatest aërial rarefaction and barometric fall, to this side the heavier air from the west will push as into a great hollow. Thus do we actually find that all storms, formed west of the Gulf Stream, are actually propagated toward it. It may be argued from the above facts that the anti-trade winds are thus maintained by storms incessantly making the circuit of the globe within the temperate zone. But in reality, instead of being the effect of storm-influence, the anti-trades are originated by independent solar agency, as are the trades, and they are potential and causal in producing the eastward progression of all cyclones. It must be conceded that the pressure of vast aërial currents does serve to force the meteor along with them as the river-eddy is carried down stream with the water-current; otherwise it is impossible to explain the westward progression of tropical hurricanes. While yet in the band of easterly trade-winds the storm will invariably work its way or be propagated toward *the most humid region*, unless mechanically borne in another direction by the great atmospheric current in which it is often embedded as an eddy in a river. The cyclone-tracks over all the oceans lie in the central bands of the great ocean-currents of high temperature and great evaporation, and the band of cyclonic violence is often beautifully coterminous with the sharply-marked edge of the Gulf Stream. Thus, in the Pacific, the Looch'oo Islands lie just in the path of the Kuro Siwo, the great Pacific Gulf Stream of the Japanese, and are visited by the most fearful typhoons; but the Bonin Islands, in the same parellel, but on the extreme margin of the Kuro Siwo, have very

mild and moderate storms.[1] "If a storm commences anywhere in the vicinity of the Gulf Stream, it naturally tends toward that stream, because," as Loomis says, "here is the greatest amount of vapor to be precipitated, and, when a storm has once encountered the Gulf Stream, it continues to follow that stream in its progress eastward." Vessels and Japanese junks, dismasted in gales off the Asiatic coast, have been drifted for many days in the current of the Kuro Siwo, to the coast of California, just as West-India beans, cocoa-nuts, and vegetables, have been drifted to Iceland, Greenland, and Spitzbergen, on the extension of the Gulf Stream. According to all meteorological observations of the tracks of storms, we are warranted in believing that cyclones and hurricanes do, as a matter of fact and of atmospheric law, run on the hot currents of the sea as naturally as the water-course clings to its bed. Practical seamen, though unable to explain the fact, are always on the lookout for these furious gales when sailing on the axial lines of the Gulf Stream, on the hot Mozambique current (the Gulf Stream of the Indian Ocean), and on the dark superheated waters of the Kuro Siwo of the Pacific.

So dangerous and disastrous are the storms which course along the Gulf Stream that sailors avoid it, and the American Sailing Directions and those of the British Admiralty advise all vessels, sailing from the West Indies to New York or Liverpool, to beware of taking advantage of its current, although it would help them along from three to four miles an hour. Close observation has traced these storms continuously from the Florida coast to New York, through Redfield's labors, and thence to England, through the record of the Cunard steamships, and thousands of detached observations.

We have now reached a point where we can properly and intelligently consider a question that has always baffled meteorologists — the *origin* of cyclones. The diagnosis of the phenomenon necessarily precedes its explanation. This subject has engrossed many minds, and various have been the ingenious devices for unravelling its mystery. Mr. Redfield — the father of storm physics — in his modesty and diffidence, so distrusted himself and in his day so keenly felt the need of a more enlarged induction of facts, that he has scarcely left us his opinion. The theories of other writers have all long since been abandoned by themselves or suffered to drop from the notice of the scientific world as evidently incapable of explaining the phenomena of cyclones. This has been the fate of them all, unless possibly we except the theory advanced by the great meteorologist, M. Dové, of Berlin. Briefly stated, the latter hypothesis is this (at least in its application to West-India hurricanes), viz., that "they owe their origin to the intrusion of the upper counter trade-wind into the lower trade-wind current" (Dové's "Law of Storms," p. 264).

[1] *See* Redfield's Report.

Without pausing here to examine this theory upon its merits and upon the facts, we hasten to mention a different hypothesis advanced, nearly two years ago, as a substitute for that of M. Dové, and as affording an entirely original and satisfactory explanation of the origin of cyclones.

The hypothesis was likewise based upon the agency of the trade-winds, but in a manner wholly different from that elaborated by the German meteorologist. In the original paper in which my views were published, the following statement was made: "It can be demonstrated that the origin of cyclones is found in the tendency of *the southeast trade-winds to invade the territory of the southeast trades, by sweeping over the equator into our hemisphere.*"

The hypothesis advanced, in lieu of another seemingly less satisfactory, claimed to rest upon observations conducted in the very region most notorious for the generation of cyclones.

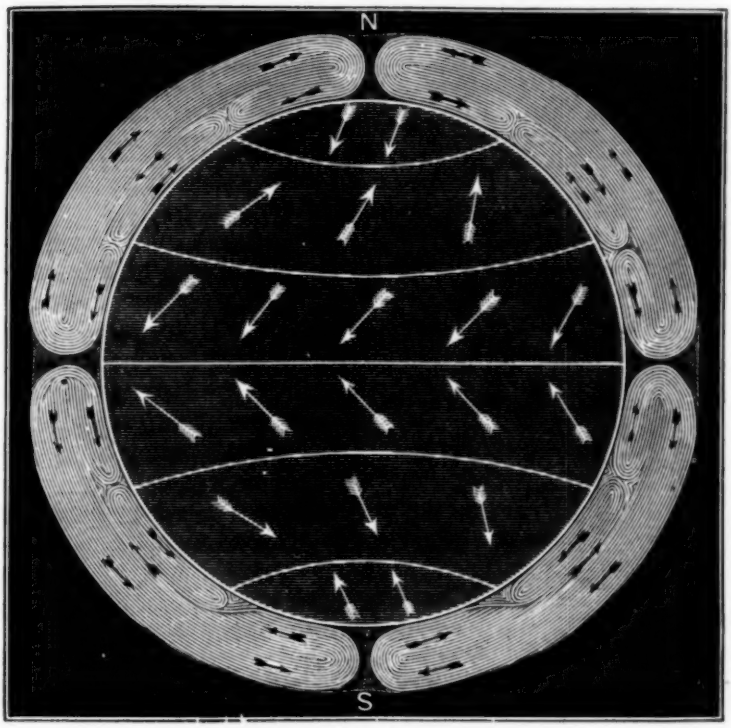
To test this, we need only to examine the Atlantic trade-winds.

Theoretically, physicial geography has generally represented the motions of the atmosphere somewhat as is represented in the accompanying diagram of the winds, as projected by Prof. William Ferrel, of Cambridge. The elaborate pages of Prof. Coffin, in his invaluable volume on the "Winds of the Northern Hemisphere," as deduced from myriads of observations, show that the graphic illustration furnished by the following diagram is approximately correct.

The region of the trade-winds, it will be seen, more than covers the torrid zone of the earth, and all seasons of the year overlaps both the northern and southern tropics. While this is theoretically true, and is usually put forth as fact, it must be accompanied with one or two important qualifications and additions.

Let us see what these are: The well-known oscillation or swinging of the belts of winds to and fro on the meridians, which is kept up in never-ceasing response to the apparent annual motion of the sun as he crosses and recrosses the equator, must ever underlie the conception we form of the trade-winds and be perpetually present to the mind's eye. This oscillation has never yet received the popular attention it needs. The sun traverses (apparently) an arc of 23½° on either side of the line; and we might, *a priori*, suppose that the thermal or meteorological equator, the thermal or meteorological Tropics of Cancer and Capricorn, and all those phenomena which lie between them and beyond them, move over an arc of as many degrees as they traverse. Such an inference, however, is not borne out by observation, and we propose to confine ourselves strictly to what may be proved by observation. It is clear that the trade-wind belt does traverse or vibrate over a wider zone than any physicist has yet assigned to it, which is not more than ten degrees of latitude north and south respectively of the Tropic of Cancer and that of Capricorn. These winds, when first experienced by Spanish sailors, gave, to that portion of the

FIG. 3.



THE ATMOSPHERIC MOVEMENTS.

Atlantic over which they blew, the name *el Golfo de las Damas* (the Ladies' Sea) because they rendered navigation so easy that a girl might take the helm. But, "gentle" as they are, they have a wide sweep, and, in the summer of the Northern Hemisphere, extend far beyond the Tropic of Cancer. They have often been distinctly felt at Madeira and the Azores (near the 40th parallel) in summer, and it is highly reasonable to suppose that they then fully reach the latitude of 40° N. The equatorial side of the northeast trade-wind belt, of course, vibrates with the sun. In summer it stretches along between the 10th and 12th parallels of north latitude, verging in August on the 13th parallel, and, according to one writer, occasionally the northeast trades at that season do not extend south of the 15th parallel of north latitude. Dampier, "the prince of navigation," as the English call him, gives the direction of the wind in the summer months, between the equator and 12° north, as south-southeast, south-southwest, and southwest.

The equatorial side of the northeast trade-wind belt in winter approaches very nearly to the equator, and may be located in January at least as far south as the latitude of 2° north.

The freshest trade-winds in the North Atlantic are generally found between the parallels of 10° and 25°, and by long-protracted experiment in seamanship they have been found to have an average propelling power, when the wind is taken just abaft the beam, of about six knots an hour. But, of course, the northern boundary of the southeast trade-wind likewise varies and vibrates with the seasons. So, also, and under the same condition, does the southern boundary of this trade vary and vibrate with the seasons. Its normal and mean position is a little south of the parallel of 25° south, but in the winter of our hemisphere it is pushed much farther south, and in the vicinity of 35° south latitude. The charts of Captain Wilkes give easterly winds for the east coast of Australia, and also for the south coast of Africa. Sir John Herschel, speaking from knowledge gained by his long residence at the Cape of Good Hope, tells us that there "the southeasterly wind which sweeps over the Southern Ocean, infringing upon the long range of rocks which terminates in the Table Mountain, is thrown up by them, makes a clean sweep over the flat table-land which forms the summit of that mountain (about 3,850 feet high), and thence plunges down with the violence of a cataract" ("Meteorology," p. 96).

From these high southern latitudes, we must conceive the motion of the southeast trades, extending northward in summer to the neighborhood of the parallel of 10°.

From the Cape of Good Hope, in a straight line toward the projecting eastern coasts of Brazil, mariners have found a peculiar streak of southeasterly winds. Between the island of Tristan da Cunha and the Cape, and northward and westward to the island of Fernando Noronha, this streak of powerful winds, with which nothing in the trade-wind region of the North Atlantic can compare, has its atmospheric current as sharply marked as the dark blue and rapid current of the Gulf Stream in the Narrows of Bemini. It is, doubtless, the region or band of most intensely acting southeast trades, and is probably due to the peculiar configuration of the shores of the South Atlantic, and to the wall of the South American Andes. It is a well-known fact that the volcanic cone of Teneriffe, which lies in the zone of northeast trades, intercepts the wind and gives it a lateral deflection; so that, while the trades are blowing strongly on the northeast side of the island, on the opposite side there is a distinctly-marked and carefully-measured calm shadow. Now, the chain of the Andes endeavors to exert on the southeastern trades just such an influence as is exerted by the Canary Islands on the northeast trades. This influence, in the former case, suffices to throw off from the Continent of South America a large body of the southeast trades, and to deflect it to the eastward, giving it the character of a south-southwest wind, and, at the same time, by forcing a greater or more concentrated body of air into the regions northeast of Brazil, imparting an increased

velocity and violence to the air-current. It is, therefore, in the air-current that the homeward-bound vessel from the Cape of Good Hope aims to steer, because she is sure of being wafted happily and swiftly to her destination.

It has long ago been demonstrated by meteorologic observations, taken both at sea and on land, that there is very much *less* atmosphere in the Southern Hemisphere than in the northern, and for a long time physicists were at a loss to account for the difference. It has been, however, very satisfactorily explained by the eminent American mathematician, Ferrel, in his work on the "Motions of Fluids and Solids, relative to the Earth's Surface," where he proves at length, and states in detail (p. 39): "As there is much more land, with higher mountain-ranges, in the Northern Hemisphere than in the southern, the resistances are greater, and consequently the eastward motion of the air, upon which the deflecting force depends, is much less; and the consequence is, that the more rapid motions of the Southern Hemisphere cause a greater depression there, and a *greater part of the atmosphere to be thrown into the Northern Hemisphere.*" It is, doubtless, to this tendency of the Southern Hemisphere to throw off much of its atmosphere north of the equator that we may attribute in part the superior force and power of the southeast trades, and their well-known ability to battle with the northeast trades, and drive them from their own territory, at least all summer, and even in winter, as far back across the line as 3° or 4° north latitude. Mr. Ferrel, speaking of the principle just enunciated, well says: "This also accounts for the mean position of the equatorial calm-belt being, in general, a little north of the equator. But, in the Pacific Ocean, where there is nearly as much water north of the equator as south (and the resistances are usually equal), its position nearly coincides with the equator." In other words, just as a bucket full of water set to revolving on a perpendicular axis would show a depression in the centre, and the fluid be thrown from all sides of its rim, the Southern Hemisphere throws its water and its atmosphere into the Northern Hemisphere, all along the equator.

It is, therefore, a mathematical and mechanical certainty that there is an invasion of the northeast trade-wind belt from the southeast trades, and observation powerfully bears out the deduction of the mathematician. Auste states, in his cautiously-written "Physical Geography:" "The southern trade-wind region is much larger than the northern in the Atlantic Ocean. In this sea, the southeast trades are fresher, and blow stronger, than the others, and often reach to the 10th or 15th parallel of north latitude; whereas, the northern trade-wind seldom gets south of the equator, and usually ranges from 9° to 29° north latitude" (p. 253). It is easy to see how easily it happens that a very small atmospheric eddy found in the tropical Atlantic by the conflictory northeast and overleaping southeast trade-winds may soon become a hurricane of wide extent and of tremendous

energy. All that is necessary, as we have before seen, is that an INITIAL IMPULSE of gyration be given to a body of air. The moment that this takes place by mechanical influence, and, centrifugal force creates the smallest eddy or vortex, the surrounding air, already highly charged with moisture, begins the process of convergence and ascensional motion, followed rapidly by condensation aloft, small, centrical, and upright.

The storm-cylinder—the nucleus of the hurricane—originally very small, is instantly enlarged and expanded by the evolution of latent heat stored away in the vesicles of aqueous vapor. For some hours, as all observations show to be actually the case, the incipient cyclone scarcely moves, while gathering in its energies and laying tributes upon all contiguous regions. The process continues with momentarily increasing intensity, and, before the sun has made his daily circuit, the meteor is formed.

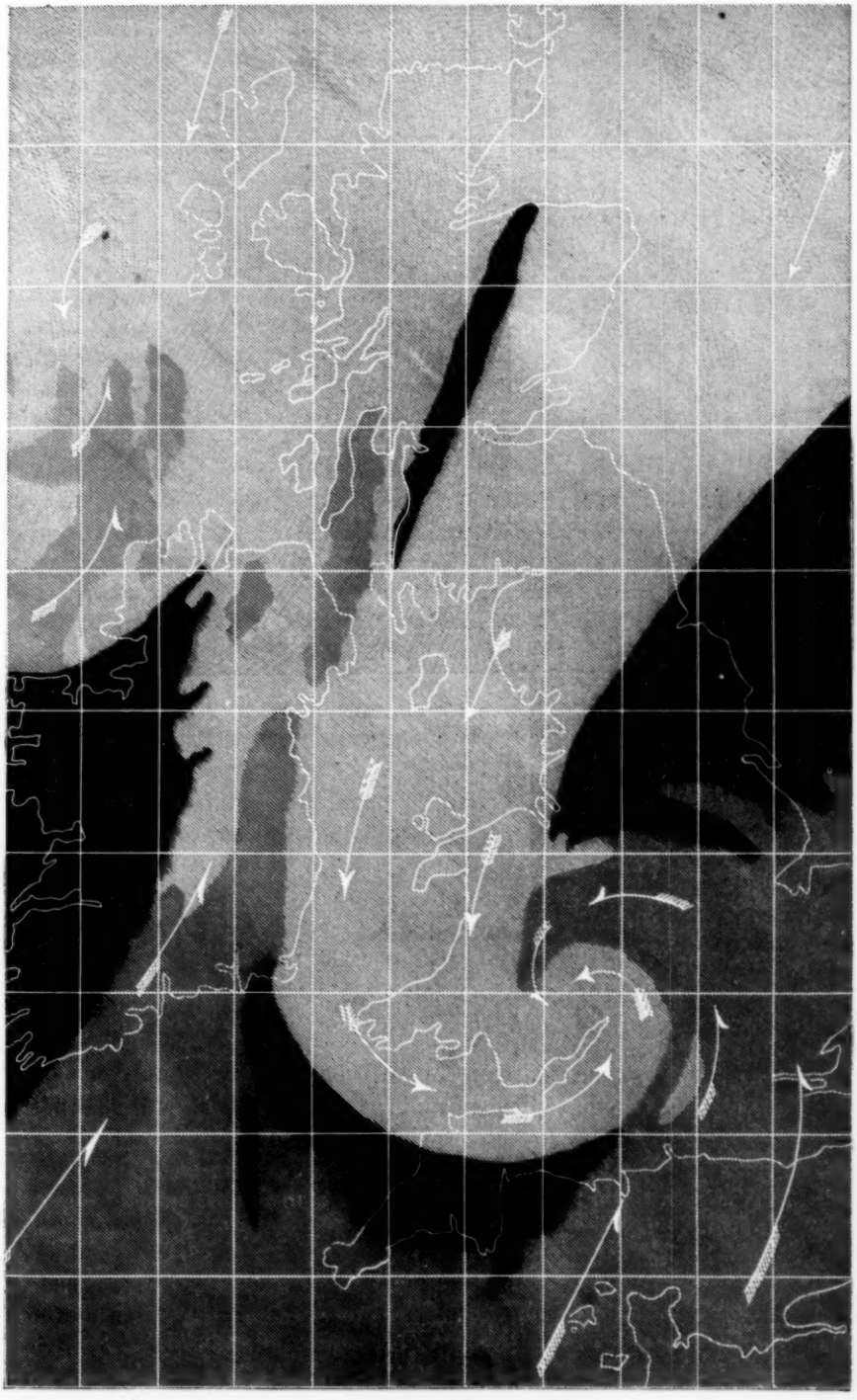
If it be asked along what parallels of latitude in our hemisphere this formation takes place, the intelligent reader will at once answer, Near the terrestrial circle of trade-wind interference. This, we have already seen, is in summer, from the 10th to the 12th parallels of north latitude.

This slender zone of debatable ground is the battle-ground of the two opposing bands of the trades. There is really no need of observations to tell us as much. But millions of observations attest the fact. Every seaman knows it. Every meteorological writer tells the same story. You have only to examine physical charts from the time of Columbus and Magellan to this, to see the absolute unanimity of testimony, and to discover that the hypothesis now advanced, and the known facts of the case, are in perfect and minute accord.

If it be asked whether the origin of the West-Indian gales is *solely* due to mechanical interference, the proper reply, it would clearly appear, should be in the negative. As the southeast trade-wind comes laden with the vapor of the southern or water hemisphere, which Dové well called "the boiler" of the globe, it is met by the cold northeast trade from the northern, or land hemisphere. There must be a great difference in their temperatures, and consequently extensive condensation, which, by the reasoning of Mr. Clement Ley, would, of itself, explain the formation of the storm. That condensation greatly assists in producing and intensifying it, cannot be doubted. In the high latitudes, where the polar air-current is sometimes forced by barometric pressure into the southerly or equatorial current moving over the warm waters of the ocean, and thus heavily vapor-laden, the consequence is illustrated by such terrific and sudden tempests as that of the Royal Charter, distinctly proved by Admiral Fitzroy to have been generated between the opposite polar and equatorial currents off the coast of Wales.

But that the origin of great depression systems is solely due to

FIG. 4.



WEATHER-CHART OF GREAT BRITAIN, BEFORE ROYAL CHARTER STORM.

Full-feathered arrows show Polar current; half-feathered arrows show Equatorial current; dark-colored surface not reported by vessels or land-observers.

condensation, can hardly be sustained, and seems entirely overthrown if we regard the single fact that, on the great equatorial belt—the belt of perennial precipitation—no hurricane or typhoon has ever been experienced by the mariner. It has long been, and is now, the universally-accepted theory of meteorologists, that the reason no cyclones have ever been known to occur on the equator is, that there the earth's rotation exerts a deflecting influence on the winds, amounting to zero, and hence the formation of a whirl is impossible. This view is not satisfactory, because the nucleus of a depression once formed on the equator, there would be intro-moving masses of air proportioned in violence to the amount of the depression and the steepness of the barometric gradient, down which they rush to reach the point of lowest barometer. The true reason that no great cyclone has ever been formed nearer the equator than the third parallels of latitude appears to be, that the equatorial belt is a belt of *calms*.

HEAT AND LIFE.

By FERNAND PAPILLON.

TRANSLATED FROM THE FRENCH BY A. R. MACDONOUGH, ESQ.

THE full solution of the question of heat and life could only be reached by simultaneous concurrence of physics, chemistry, and biology. Ancient physiology treated of animal heat empirically, but was unable to explain its origin. That result required the discoveries of Lavoisier and the more modern researches of thermo-chemistry. After revealing the source of that heat, it was important to show how it was disposed of; and this is taught us by thermo-dynamics. And, in conclusion, only the most delicate physiological experiments could settle the modifications that take place in living beings, when subjected to the influence of a temperature either above or below that they possess normally. Medicine and hygiene already benefit by the indications yielded by pure science upon this subject. It is admitted that the study of the variations of animal heat in diseases is of the highest consequence for their comprehension, and that both diagnosis and prognosis receive unexpected light from it.

An inquiry into calorific phenomena, undertaken from various separate and independent points of view, for the solution of questions that seemed at first sight to have no mutual connection whatever, has thus obtained a body of truths which enter into combination almost of their own accord at the present time, and are found to contain the secret of a great problem in natural philosophy. A minute and

extended analysis has thus resulted in an instructive synthesis, which is one of the most signal acquisitions of the experimental method.

I.

All animals have a temperature above that of the gaseous or fluid media in which they live; that is to say, they all possess the faculty of producing heat. Warm-blooded animals maintain an almost constant temperature in all latitudes and all climates. Thus, in polar regions, man, mammals, and birds, mark only one or two degrees less than they do at the tropics. The mean temperature of birds is 41° (cent.), and that of mammals 37°. Those animals called cold-blooded produce heat also, though in a less degree; but their temperature follows the variations of that of the surrounding medium, keeping, however, a temperature a few degrees higher than it. In reptiles, this excess varies from 5° to half a degree; in fish and insects, it is still smaller; and, in the wholly inferior species, it rarely reaches half a degree. In fine, with animals that vary in temperature, the power of resistance to external causes of refrigeration increases in proportion to the perfection of the organization. It is observed, too, that in these beings vital activity and the force of respiration have a direct relation to the thermometric state; thus, in a medium of 7°, lizards consume eight times less oxygen than at 23°. With animals of constant temperature, the reverse is the case; the colder it is, the more active is their respiration: a man, for instance, who, in summer, consumes only a fraction over an ounce of oxygen an hour, in winter consumes more than an ounce and a half. Apart from the state of the surrounding medium, many different circumstances exert a perceptible influence on animal heat, and produce tolerably regular variations in it. The seasons, the times of day, sleep, digestion, mode of nourishment, age, etc., are thus constant modifiers of intensity of combustion in breathing; but there are such order and harmony, such foresight, one may say, in the organization of the system, that its temperature continues definitively nearly the same in the physiological state.

The temperature of the human body, at the root of the tongue or under the armpit, is about 37° (cent.); this figure expresses the mean found in taking the temperatures of different points of the body, for there are certain slight variations in this respect in passing from one organ to another. The skin is the coolest part, and the more so the nearer we come to the extremities. The temperature rises, on the contrary, with increasing depth of penetration into the organism; cavities are much warmer than surfaces. The brain is cooler than the viscera of the trunk, and the cellular tissue cooler than the muscles. Nor does the blood have the same temperature in all parts of the body. The labors of Davy and Becquerel established the fact that the blood is warmer the nearer to the heart examinations are made. Claude Bernard measured, by methods of equal ingenuity and exact-

ness, the temperature of deep vessels and the cavities of the heart. He showed that blood, in passing out from the kidneys, is warmer than when it enters, and the same is true of blood passing through the liver. He ascertained, too, that the vital fluid is chilled in going through the lungs, and consequently the temperature of the left cavities of the heart is lower than that of the right, by an average of two-tenths of a degree. The last fact clearly proves that the lungs are not the furnace of animal heat, and that the blood, in the act of revivification, grows cool instead of warm.

Ancient physiologists supposed that life has the power of producing heat; they conceived of a kind of calorific force in organized beings. Galen imagined that heat is innate in the heart—the chemic-physicians attributed it to fermentations, the mechanic-physicians to frictions. Time has dispelled these errors of supposition, and it is proved now that the heat of animals proceeds from chemical reactions taking place in the interior of the system. Lavoisier must be credited with the demonstration of this truth by experiment. As early as 1777 he discovered that air, passing through the lungs, undergoes a decomposition identical with that which takes place in the combustion of coal. Now, in the latter phenomenon, heat is thrown off; "therefore," says Lavoisier, "there must be a like release of heat in the interior of the lungs, during the interval between inspiration and expiration, and it is doubtless this caloric, diffusing itself with the blood throughout the animal economy, which keeps up a constant heat in it. There is, then, a constant relation between the heat of the living being and the quantity of air introduced into the lungs, to be there converted into carbonic acid." Such is the first capital fact brought to light by the creator of modern chemistry; but he did not rest there. He undertook to examine whether the heat theoretically produced in a given time by the formation of a certain amount of carbonic acid, that is to say, by the combustion of a certain quantity of carbon in the organism, is exactly equal to the amount of heat developed by the animal in a corresponding time. This quantity was estimated by the weight of ice melted by the animal placed in a calorimeter. Lavoisier ascertained in this way that such equality does not exist, nor was he long surprised at this, for he soon discovered that, of 100 parts of atmospheric oxygen absorbed, only 81 are thrown off by the breath in the form of carbonic acid. He concluded then, from this observation, that the phenomenon is not a simple one, that a part of the oxygen (nine per cent.) is consumed in burning hydrogen, to form the vapor of water contained in the expired air. Animal heat must be accounted for, then, by a double combustion: of carbon first, then of hydrogen; and respiration regarded as throwing off out of the animal carbonic acid and vapor of water.

Lavoisier's experiments have been repeated and varied, and his conclusions discussed in many ways for nearly a hundred years.

Several experimenters have corrected or perfected some points, but the general doctrine has not been shaken by the recognition of its secondary and very subtle difficulties, several of which still puzzle physiologists. It is, indeed, undeniable that the greater part of the reactions which occur in the system, with the production of heat, do bring out, as a result, the exhalation of watery vapor and carbonic acid from the lungs; but these two gases cannot arise from a direct combustion of hydrogen and carbon, because the system does not contain such substances in a free state. They represent really only the close of a succession of transformations, often distinct from combustions, properly so called. On the other hand, these are not the only residue of the chemical operations performed in the vital furnace. Besides the water and carbonic acid thrown off by animals in breathing, which are like the smoke of this elaboration of nutrition, they excrete by other channels certain principles which are, as it were, the scoriæ. Now, these principles of disassimilation, among which should be noted urea, uric acid, creatine, cholesterine, etc., could not be results of pure combustion, and they denote that the circulating current is the seat of extremely manifold reactions, the laws of which we are only beginning to gain a glimpse of.

The latest advances of chemistry allow us, indeed, to follow the linked sequence of the gradual transformations of nutritive substances into the cycle of vital operations. It is well, at the outset, to fix exactly the seat of these phenomena. They take place in all the points of the system traversed by the capillary vessels. The glands, the muscles, the viscera, in brief, all the organs, are in a state of constant burning—they are every instant receiving oxygen, which brings about alterations of various kinds in the depth of their substance. In a word, every organ breathes at all its points at once, and breathes in its special way. Certain physiologists of the present day are wrong in localizing the phenomena of breathing in the capillary vessels. They are merely the channels of transfer for oxygen, which, by exosmosis, penetrates their thin walls, and then effects, by direct contact with the smallest particles of the organized mass, the chemical action which keeps up the fire of life. It is easy to prove this by placing any tissue, lately detached from the body, in an oxygenated medium. We remark in this case an escape of carbonic acid, together with a development of heat, and this possibility of breathing outside the system proves clearly that such act can be accurately compared, as Lavoisier thought, to the combustion of any substance. The only difference is with regard to intensity. While a candle or a bit of wood burns rapidly, with a flame, the combustible materials of organic pulp unite with oxygen in a more slow and quiet manner, less violently and manifestly.

The blood, which flows and reflows incessantly in the most slender vessels of our bodies, and charges itself full with oxygen every time

the chest heaves, is composed of very various substances. It contains mineral salts, such as chlorures, sulphates, phosphates of potassium, soda, lime, magnesia, coloring-matters, fatty particles, neutral substances of the nature of starch, and nitrogenized products, such as albumen and fibrin. The salts undergo slight changes in the torrent of circulation; they are eliminated by the chief emunctories. The neutral matters of the nature of starch are converted into glycogene and fat. The fatty particles undergo in the blood only such oxidizations as produce certain derivatives of the same order. And, last, the nitrogenized products are made over into fibrin, musculin, ossëin, pepsin, pancreatin, compounds all differing very slightly. It is the first portion of the chemical process which is effected in the principal fluid of the body. All these materials, elaborated at different points of the circulating current, and designed to be assimilated, are destroyed in the very organs in which they had been fixed. The glycogene is transformed into sugar, which is burned, yielding water and carbonic acid; the fatty acids are partly eliminated by the skin, and partly burned. As to the plastic matters which form the web of the tissues, we know little about the chemical relation which connects these with their products of destruction—urea, creatine, cholesterine, uric acid, and xanthine. Such is a rapid sketch of the principal chemical phenomena which, taking place throughout the entire system, kindle everywhere an evolution of more or less intense heat. There is no central organ, then, for feeding the vital fire—every anatomical element performs its share; and, if a nearly uniform temperature exists throughout the body, it is because the blood diffuses heat regularly into the various parts it bathes.

Now, how can the amount of heat to which these reactions may give rise be ascertained? Lavoisier arrived at it in a very simple manner. After comparing the oxygen absorbed by the animal with the carbonic acid and watery vapor thrown off, he deduced the weight of the carbon and hydrogen burned, by assuming that the formation of carbonic acid and of water produces in the system the same amount of heat that it would produce if taking place by means of free carbon and hydrogen. This is very nearly the result he obtained: A man weighing 132 pounds burns in 24 hours, at the average temperature of Paris, very nearly 11 ounces of carbon, and $\frac{11}{14}$ of an ounce of hydrogen, and thus develops 3,297 heat units. During the same period he loses through his lungs and skin $2\frac{3}{4}$ pounds of watery vapor, which take from him 697 heat-units. There remain, then, nearly 2,600 heat-units to account for. Other analogous estimates have been made, and physiologists have deduced from them the conclusion that a man of average weight produces in our climate 3,250 heat-units every day; that is to say, a sufficient amount of heat to raise seven gallons of water to the boiling-point. These figures, though approximations, give a sufficiently clear notion of the power of the animal economy to generate heat.

Of late years, the question has been taken up again with more exactness, thanks to the views of a new science called "heat-chemistry," which occupies itself with chemical phenomena in their relations to heat. Heat-chemistry, by the aid of very delicate apparatus for measuring heat, ascertains the number of heat-units developed or absorbed by bodies entering into combination, beginning with the noted experiments of Favre and Silbermann. Berthelot, who had made profound researches into this subject, reduces the sources of animal heat to five varieties of transformation: first, the effects resulting from the fixation of oxygen with different organic principles; then the production of carbonic acid by oxidization; then the production of water; in the fourth place, the formation of carbonic acid by decomposition; and, last, hydrations and dehydrations. The learned chemist attempted to show how the numbers obtained in the study of the heat of combustion of the different organic acids, alcohols, etc., might be applied to the compounds burned in the animal organism; but, while admitting the theoretic verity of the analogies he establishes, we cannot refrain from remarking that their practical verification is exceedingly delicate and difficult. How can we measure, at any one point of the system, the heat produced by a fleeting reaction occurring in the inmost depths of a tissue that must be lacerated to be examined?

If thermo-chemistry seems not to throw much light on physiology on this side, it reveals to it on another sources of heat that had hitherto escaped notice. Berthelot shows that carbonic acid in the system is not always formed by oxidization of carbon, but sometimes proceeds from decomposition absorbing heat. We know that alimentary substances are reducible to three fundamental types—fats, hydrates of carbon (sugars, fecula, starch), and the albuminoids. Now, the fats, in decomposing and combining with water, as it occurs under the influence of the pancreatic juice, evolve heat; and so it is with the hydrates of carbon, independent of any oxidization. And albuminous substances, too, produce very clear calorific phenomena, when their combination with water takes place with its consequent various decompositions. These facts, noted by Berthelot, must have their place in the minute and exact calculation of animal heat, which it is perhaps as yet too early to undertake. At any rate, this heat originates in the totality of those chemical transformations which are going on unceasingly in the depths of the animal organs, and are bringing about the continual renovation of the whole organized substance; in other words, nutrition; but why that nutrition—why that perpetual production of heat in the living machine?

We have now the means of answering this question, which involves the secret of one of Nature's most beautiful arrangements. The heat produced by animals is the source of all their movements; in other words, the mechanical labor they perform is a mere simple transformation of the activity of heat they develop. They do not create mo-

tive force by any voluntary operation, which would be one of the prerogatives of life; they draw it from the calorific energy stored up in the organs traversed by the blood. Besides, there is a fixed relation between the quantity of heat that disappears and the mechanical labor that appears. Yet, it is to be remarked that, if all motion by living beings is a transformation of animal heat, that heat is not wholly transformed into motion. It is partly wasted by transpiration through the skin, by touch, and especially by radiation; it is used in keeping up to a constant point the temperature of the animal, subjected to many causes of refrigeration.

The mechanical labor performed by an animal is very complex. Independently of visible muscular motions, there are all the changes of place in the interior organs, the continual passage of the blood, the contractions and dilatations of a great number of parts. Now, these actions are only possible in so far as the phenomena of breathing are taking place in the active region. Prevent arterial blood from coming to the muscle, that is to say, prevent combustion taking place, and consequent heat evolving in it, and, although the structure of the organ suffers no harm, it loses its contractile power. Mere compression of the supplying artery of the muscle, so as to check the flow of blood in it, causes the organ to grow cool, and lose its power. The labors of Hirn and Béclard have clearly established the relations between heat and muscular motion. Later experiments by Onimus have fixed, with equal precision, the efficiency of heat through the movements of circulation.

We have said that the heat-producing power of aliments will be the more considerable in proportion as they contain a greater quantity of elements that need a large supply of oxygen for their combustion. Therefore, meat and fats repair the losses of the system much more speedily than vegetable substances. The latter are suitable for the inhabitants of warm countries who do not require to produce heat, which the atmosphere supplies them with abundantly. The inhabitants of cold regions, on the contrary, whose accessions of heat ought to be as continual as energetic, are urged by instinct to use meats and fats, which throw out great heat in their combustion. For instance, it is a physiological necessity that the Lapps should feed on the oil of cetacea, as it is a necessity for men of the tropics to consume only very light food. The activity of respiratory combustion and the kind of alimentation thus vary with climate, so that there is always a certain proportion maintained between the thermic state of the surrounding medium and that of the animal furnace. In like manner, in the same climate, persons who perform great mechanical labor must eat more than those who put forth but little movement. This fact, long ago observed, has received of late the clearest and surest demonstration. Yet, perhaps, it is not kept sufficiently in view in the management of public alimentation. Many examples prove the benefit that industry would de-

rive from increasing, in all possible ways, the amount of meat used in laborers' meals. Quite recently, at a manufacturing establishment of the Tarn, M. Talabot has improved the strength and sanitary condition of his workmen by giving them meat in abundance. Under the influence of a diet almost wholly vegetable, each laborer lost on an average fifteen days work a year through fatigue or sickness. As soon as the use of meat was adopted, the average loss for each man per year was not over three days. Often enough, it must be owned, alcohol is only the workman's means of remedying the want of heat-producing elements in his food; a deceitful remedy, which buoys up the system for a time, only to sap it afterward with alarming subtlety. One of the best preventives of the abuse of alcohol would certainly be the lessening of the cost of meat.

From the point of view of the relation between heat and motion, the living being may thus be compared to an inanimate motor, as a steam-engine. In both cases, heat is engendered by combustion, and transformed into mechanical work by a system of organs more or less complex. In both cases it is at first in a state of tension, and yields motion in proportion as it is demanded for the performance of certain work. Only the living being is the far more perfect machine. While the best-made steam-engines only utilize $\frac{12}{100}$ of the disposable force, the muscular system of man, according to Hirn, accounts for $\frac{18}{100}$. On the other hand, the animated motor has this peculiarity, that its sources of heat and its mechanical arrangements are intimately commingled, that its heat is produced by organs in motion with a sort of general diffusion, and that the machine itself becomes in turn transformed within itself into heat; an incredible complication, of which science has succeeded in unravelling the simple laws only by dint of the united efforts and resources of physics, chemistry, and biology.

As some physiologists hold, heat must not only be the source of motion in the system, but must also undergo transformation into nervous activity. The functional action of the brain must be a labor, exactly like that of the biceps. Mind itself should be regarded as engendered by heat. Late experiments by Valentin, Lombard, Byasson, and especially Schiff, would seem to prove, it is thought, that there is a proportional and constant relation between the energy of nervous functions and the heat of the parts in which they are effected. Gavarret boldly concludes, from his researches, that heat has the same relations to the nervous system that it has to the muscular system; only, in the case of the muscles, the force produced exhibits itself externally by visible phenomena, while in that of the nerves it is exhausted internally in profound molecular action, which eludes any exact measurement. A given sum of heat developed in the system would thus be on one side a mechanical equivalent, and on the other a psychological equivalent. Gavarret, who is a cautious *savant* and true to experimental methods, doubtless does not go so far as to maintain that

thought and feeling can be estimated in heat-units; he even asserts that there is no common measure between intelligence and heat; but less timid physiologists are not wanting who reduce every kind of vital manifestation to the strict laws of thermo-dynamics. A few succinct remarks may perhaps show that such physiologists err.

A comparison between the muscular and the nervous systems from the point of view of their connection with heat is a bold one for many reasons. Between nerve and muscle there exists this enormous difference—that the former is endowed with a spontaneity denied to the latter. Muscular fibre never contracts of its own accord; it needs a stimulus—its energy is borrowed. The nerve-cell, on the contrary, has in itself an ever-present, never-exhausted power of action, of which the energy is its peculiar property. Both evidently derive the principle of the activity that marks them from the same external and internal media; but, while the muscle, a mechanical organ, is limited to the obedient transformation of the force assigned to it, under the form of heat, into a measurable amount of work, the nerve, a vital organ, remains impenetrable and inaccessible to our calculations, and exerts its characteristic and sovereign powers in its own way, through a series of operations that escape all estimates of their force and heat. On the part of the muscular system, every thing can be measured; on the part of the nervous system, nothing. Impressions, sensations, affections, thoughts, desires, pleasures, and pains, make up a world withdrawn from the common conditions of determination. That superior force which, ruling all the highest animal activities, decides, suspends, checks, and governs the very transformation of heat into movement; which, asserting its independence within us, call it by what oldest name we may—soul, will, or freedom—remains the most undeniable, though the most mysterious certainty of our consciousness, this force protests against the degradation of cerebral life to mechanism. Such is the conviction, moreover, of Claude Bernard and of Helmholtz.

II.

Independently of the slight and usual variations that heat may present in the same species, and those it exhibits in passing from one zoological group to another, we may consider the changes it undergoes in the same individual, influenced by the various disturbances of the system. Although it remains almost insensible to modifications of the surrounding temperature, it is not the same when the complete equilibrium of the organs is affected. The concord between the different parts of the organism and the functions they discharge is so perfect that the least trouble is reflected among them, and sends disorder everywhere. The nervous system, charged with keeping up harmonious communication between all points of the living being, first takes note of the change befalling, and transmits its abnormal impression into all quarters. It is not the generator, but it is the regulator, of

animal heat; that is to say, it directs and in a manner oversees its production and diffusion according to the varying needs of the system. Every lesion or affection of this system reacts on the physiological processes, and particularly on the evolution of heat. By cutting the filament of the great sympathetic nerve on only one side of a rabbit's neck, Claude Bernard produced an elevation of temperature of several degrees on that side. The blood flows toward the point where the action of the nervous system is suspended under any influence whatever, bringing with it an increase of heating force. At a point where the reverse occurs, the vessels contract, and the temperature falls.

Imperfect nutrition and fasting act on the animal heat, but not directly. The organism keeps up to its normal degree of temperature till it has exhausted its reserved store of combustible substances. Then it cools slowly down to a much lower degree. Thus, a rabbit, starved by Chassat, showed the first day a warmth of 38° 4′ (cent.); two days before its death, 38° 1′; the evening before, 37° 5′; and at the moment of death, 27°. By placing it in a warm medium the moment it was about to die, the apparent activity of its functions was restored for a little while; but the renewal is of brief duration: the anatomical elements have absolutely lost their spring.

The hand of an invalid, suffering from inflammation of the chest, or from an attack of fever, is burning; that of one affected by serious asthma, or by emphysema, is as cold to the touch as marble. This is because animal heat varies greatly in different pathological states. Sometimes it rises, sometimes it falls; and the morbid influence is scarcely ever compatible with the body's degree of normal temperature. In Hippocrates's time, when examination of the pulse was not yet practised, the increase of temperature was the only element in the commonest of maladies, fever. Galen defines it quite simply as an extraordinary heat (*calor præternaturalis substantia febrium*). The ancients did not err. It has been admitted and proved in our days, that the elevation of the animal heat is just the specific character of the febrile condition. On the one hand, there is never any fever when the temperature continues at the normal degree; on the other, the rapidity of the pulse may reach the utmost limits, without any febrile movement, as is seen in hysteria. Whenever the bodily heat exceeds 38° (cent.), it may be affirmed that there is fever; and, whenever it falls below 36°, there is what is termed algidity. So that the normal heat varies within the narrow range of scarcely two degrees. Beyond these limits, that is, above 38° and below 36°, the temperature points out some morbid trouble. In common intermittent fever, it rises two or three hours before the chill, reaches a maximum at the close of it, and then falls. Acute and decided inflammations, such as pneumonia, pleurisy, bronchitis, erysipelas, etc., are marked by a period of thirty-six hours, or about two days, during which the heat rises slowly to 41°. Toward the third day, this heat decreases, ready to reappear in exacer-

bations of from half a degree to a degree, during three or seven days, at the end of which time the disorder has run its course. When the temperature gradually rises after the third day, a fatal result may be expected. Persistent heat in that case is the precursor of death. Eruptive fevers, like small-pox, scarlatina, and measles, present very important phenomena of heat. In these heat begins with the attack of the malady, and increases till the cutaneous eruption occurs. It keeps up at a maximum, which reaches 42½° (in scarlatina), till the eruption is complete, then it begins a declining course, variable with the phases of the eruption, which finishes either with scaling off as in scarlatina, or suppuration as in small-pox. And the temperature rises also in several surgical affections, bringing on a more or less inflamed and feverish condition. This is observed in wounds, and generally in every kind of traumatism, in tetanus, aneurisms, etc. In the case of strangulated hernia and of burns, and in most cases of poisoning, on the other hand, it declines in a remarkable way.

Very plainly this rising and falling of animal warmth in diseases can only be attributed to a corresponding state occurring in the energy of respiratory combustion. We do not yet exactly know the cause of these variations; that is, the mechanism by which the morbid influences stimulate or check the active production of heat. Some physicians see in it the effect of fermentations occasioned in the blood by certain microscopic beings, such as bacteria and vibriones, which may perhaps be supposed to be the fact in most febrile maladies. Others assume that, in local inflammations, it is the inflamed organ which communicates heat to the whole body, as a furnace does in a confined space. To others the disturbance seems rather to have a nervous origin, since the nerves, as we have seen, are the regulators of thermic action.

The use of the thermometer is the only exact method of measuring the temperature in diseases. Swammerdam, in the middle of the seventeenth century, seems to have been the first to have the idea of it. De Haën and Hunter, in the last century, used it in their medical practice, but its employment at the sick-bed has really only come into importance in our own day, thanks to the labors of Bouilland, Gavarret, Roger, Hirtz, and Charcot, in France; Bärensprung, Traube, and especially Wunderlich, in Germany. These physicians were not content with proving that the temperature in illness rises several degrees; they followed the variations of the thermometer day by day, hour by hour, in the different phases of the pathologic movements. They discovered that the curves of these oscillations furnish constant types for each disease, which are modified in a regular manner, according as the disease has been left to itself or treated by one or another medicine. By the study of these pathologic curves of heat the course of diseases may be followed, and valuable indications noted in diagnosis or prognosis. In hæmorrhage of the brain, for instance, the temperature falls

suddenly to 36° or even 35°, while, in the attack that takes the form of apoplexy, it continues nearly at 38°. These two disorders, quite distinct in their treatment and cure, yet often give rise to a confusion, which the thermometer will hereafter allow to be avoided. Granular meningitis is distinguished from simple meningitis by the same method; in the former the temperature does not rise, notwithstanding the extreme rapidity of the pulse, but in the latter the thermometer marks 40° or 41°.

In every case we see what advantage practical medicine may gain from the physical sciences, what precision and safety it attains by the employment of its means, in proportion to the morbid symptoms. We may add that the future of diagnosis is to be found partly here. By the banishment from medical examination of the often-uncertain judgment of the senses, by substituting as far as possible for personal and arbitrary conclusions, as well as for the feeling, always more or less confused, of the physician, the plain and impassive indications of an exact instrument, we do away with the causes that impede the methodical interpretation of the evil in question. Moreover, these instruments often reveal peculiarities that elude direct observation. They repair the omissions, correct the mistakes, guide the activity, multiply the power of our imperfect senses. From this point of view, the study, by the thermometer, of variations of animal heat in diseases, thermometric clinic, as it is called, is one of the most indisputable onward steps in medicine.

III.

After having seen how internal heat is produced in animals, how it expends itself in them, and undergoes change into mechanical work, in fine, what spontaneous or occasional changes it passes through in them, we should study the influence of external heat on the same animals, and the various phenomena resulting from the rise or fall of temperature in the medium they live in. Quite recent researches have thrown light on these questions. Boerhaave had made some experiments, not sufficiently exact, however, on the subject. Berger and Delaroche, at the beginning of this century, undertook new ones, which gained celebrity in the schools of physiology. They placed animals in stoves containing air heated to different degrees of temperature, and noted the effects produced on life by thermic influences. The conclusion from their researches was, that all animals have the power of resisting heat for a certain length of time, and that the duration of resistance varies with the species. Small animals yield after a moderate time to a temperature of 45° to 50° (cent.). Larger ones endure heat better. Cold-blooded animals and the larvæ of insects resist more energetically than warm-blooded animals; but the reverse is the case with fully-developed insects.

Delaroche and Berger studied the human subject, too, from the

same point of view, and ascertained that the effect produced varies with individuals. Thus from 49° to 58° the stove grew insupportable to Delaroche himself, who became ill from the experiment, while Berger was scarcely fatigued by it. On the other hand, Berger could remain only seven minutes in a medium heated to 87°, while Blagden stayed 12 minutes in it. In tropical countries the heat often rises during the day above 40° without troubling the natives. At the Cape of Good Hope the thermometer marks 43°. Yet sometimes such a heat is murderous. It is related, among other cases, that in the month of June, 1738, in the streets of Charleston, several persons died under the influence of 41°. In Africa our soldiers are often known to be attacked with madness and to die in making a long march, under the rays of a burning sun, but here the influence of light is combined with that of heat. Duhamel mentions the account of several servant-girls of a baker, who could remain without any inconvenience at all for nearly ten minutes in an oven heated to the necessary degree for baking bread. The experiment has since been repeated. There is nothing contradictory in these facts. An animal can endure for some time a temperature much higher than its own, because the very profuse transpiration which occurs in such a case prevents the heating of the organs; yet, as we shall see, so soon as the internal heat really rises a few degrees above the normal figure, life is no longer possible.

The study of these phenomena had scarcely been carried further, when in 1842 Claude Bernard devoted to it certain researches, which he resumed and finished last year, and of which he has just published the results. This physiologist used a pine box, divided into two parts by a grating, on which the animal subjected to the experiment is placed. The box rests on a cast-iron plate, and the whole is arranged on a furnace which warms the air of the apparatus more or less. A window, placed in the side of the box, allows the head of the animal to be fixed outside of it at will. Examining animals, subjected under these conditions to the influence of air more or less warm, Bernard verified the first observations of Berger and Delaroche, and made new and more important ones. Boerhaave had given as the cause of death the application of hot air to the lungs, preventing the cooling of the blood. Bernard showed by experiments that hot air, acting on the skin, creates a rise of temperature more rapidly fatal than when this fluid is merely introduced into the pulmonary vessels. He proved also that, when the hot air is damp, the phenomena take a more rapid course, and death occurs much more quickly and at a lower temperature than in dry air. This difference must result from the fact that dampness promotes a rise in temperature.

When an animal is subjected to the poisoning effects of heat, it presents a series of uniform and characteristic phenomena. It is at first a little disturbed, then panting, its movements of respiration and circulation accelerate, it grows slowly hotter through the circulation,

which, carrying the blood continually from the surface to the centre, bears heat also along with it, then at a given moment it falls into convulsions, the beating of its heart ceases, and it dies uttering a cry. By means of the thermometer it is noted that the temperature of the animal, in every case, is higher by four or five degrees (cent.) than the figure which represents the normal warmth. Thus at first the animal is excited, its functions seem to be performed with fresh vigor, very much as, in the first rays of April sunshine, the pulsations of life in all beings become more rapid; but this stimulus is only fleeting, and soon, when it reaches a certain degree, this heat gives place to the cold of death. Bernard carefully examined animals dying under these conditions, and the first phenomenon that struck him was the rapidity with which corpse-like rigidity came on. The heart grew suddenly insensible to any stimulus; effused spots appeared at several points on the skin. The heat fixed in coagulation the soft matter that composes the muscular fibres. These had the look of being struck with lightning. On the other hand, the arterial blood of the animal grew black, ill-supplied with oxygen, overloaded with carbonic acid, and assumed the look of venous blood. Yet in this state the blood has not lost its physiological properties, and under the influence of a new supply of oxygen can regain its normal state, and grow ruddy again. The heat, provided the degree be not too elevated, only promotes activity in sanguine combustion, without changing the blood. Nor does the nervous system either appear to suffer much. The element most deeply affected is muscle; *heat is a poison of the muscular system*, like sulpho-cyanuret of potassium, and the upas-antiar. It is the loss of the vital properties of this system, which, by bringing about rigidity of the muscles, then the stoppage of circulation, and consequently of respiration, is a necessary cause of death. This destruction of the contractile muscular fibre occurs toward 37° or 39° in cold-blooded animals, toward 43° or 44° in mammals, toward 46° or 48° in birds, that is, speaking generally, at a temperature five or six degrees higher than the natural temperature of the animal. Bernard calls attention to the fact that in no case is it allowable to suppose that life opposes a kind of resistance to the excessive heating; on the contrary, vital movement tends to quicken it, and that may be readily understood. The internal heat produced by the animal unites with the acquired heat, and the renewal of the blood, which is the condition of the heating, then occurs with much greater activity. Let us add that quite lately Demarquay applied this toxic action of heat on the muscles in the happiest manner, and without suspecting it. He cured patients suffering from those frightful muscular contractions which characterize tetanus, by subjecting them to the influence of caloric, and making them take very hot air-baths. The rise of temperature in the tetanized muscles was sufficient to modify them, and restore them to a healthy state. Here the poison worked a cure.

Such are the effects on animals of the elevation of temperature. Let us now see what becomes of them when immersed in cold media. Some curious facts with respect to the freezing of certain animals have long been known. During his voyage to Iceland, in 1828 or 1829, Gaimard, having exposed in the open air a box filled with earth in which toads were put, opening it after a certain time, found the reptiles frozen, hard and brittle; but they could be restored to life when put in warm water. Many ancient authors cite similar cases, and we can almost bring ourselves to understand how a great English physiologist might for a moment have given them the whimsical interpretation that he did. John Hunter fancied it might be possible to prolong life indefinitely by placing a man in a very cold climate, and there subjecting him to periodical freezing. The man, he said, would perhaps live a thousand years, if, at the end of every ten years, he were frozen for a hundred, then thawed out at the end of the term for ten years more, and so continuously. "Like all inventors," Hunter adds, "I expected to make my fortune by this scheme, but an experiment completely undeceived me." Putting carp into a freezing mixture, he observed, in fact, that, after being entirely frozen, they were dead, past recovery. The case is the same with all other animals, as the late and very remarkable experiments of F. A. Pouchet have proved.

The influence of cold on organized beings varies, according as we regard superior animals or the inferior species. In general, it may be said that it requires a very low surrounding temperature to chill many animals, because the vital heat they develop resists the process with energy. Yet the mammals of arctic regions, in spite of their thick coat of fur, can only brave the temperature of the pole (sometimes equal to 40° (cent.) below zero, the freezing point of mercury) by living under the snow where they make their lair. The Esquimaux, too, dig huts in it, where they pass their wretched days. When the organism can neither react nor protect itself against temperatures so low, death by freezing quickly overtakes it. The body is stiffened, and retains afterward a state of remarkable incorruptibility. Every one knows the story of the antediluvian mammoths, discovered in the polar ice, where they had been buried, as fresh as animals just dead. While heat destroys the tissues, cold preserves them.

Through what mechanical means does cold become mortal? It seems to act on the nervous system. Travellers relate that in polar regions an unconquerable disposition to sleep overcomes men attacked by very low temperatures. On the icy shores of Terra del Fuego, Solander said to his companions, "Whoever sits down falls asleep, and whoever falls asleep never wakes again." This inclination is so overpowering that many of his attendants gave up to it, and he himself sank down for a moment on the snow. It is said that, during the winter of 1700, two thousand soldiers of Charles XII.'s army perished in the sleep to which they surrendered, under the influ-

ence of cold. Its action on the nervous centres, however, is only secondary and consequent on another phenomenon, studied by Pouchet, which reveals this as the secret of death. When the temperature of the interior of the body sinks to 10° or 12° below zero (cent.) the cold freezes the blood more or less, thoroughly disorganizing its globules, and it is this alteration which, either at once or when the blood becomes fluid again, destroys all the vital functions. Larrey relates the case of Sureau, chief apothecary of the French army in Russia, who, when chilled to freezing by a painful march in the snow, did not die until the moment they began to restore warmth. Experiments on animals show that they keep themselves alive as long as they are maintained in a state of half congelation, and die whenever their temperature and circulation are so far restored as to permit the blood-globules, disorganized by cold, to be diffused throughout the vessels. Death occurs, therefore, whenever the quantity of these globules is sufficient to produce a considerable disturbance in the system, that is, whenever the frozen part is at all extensive. An animal entirely frozen, and consequently containing in its congealed blood no globules but those unfit for life, is dead, without possibility of resurrection. Thawing it only restores a soft flaccid, discolored body, with opaque eyes. If freezing only attacks a limb, it becomes gangrenous, and is destroyed. Pouchet deduced from these examinations a judicious, practical conclusion. If it is true that, in cases of partial freezing, the death of the individual is due to the disorganized globules reëntering the circulation and corrupting the blood, it is plain that, the more sudden the invasion of these globules is, the more rapidly death will supervene. It follows, that, by resisting this invasion, by means of ligatures, or extremely slow thawing, we might succeed in preventing the poisoning. The diseased globules which, pouring in a flood into the heart and lungs, would imperil life by the sudden alteration of the blood, will apparently disturb it merely in an unimportant way, if they are dropped into the blood by slow degrees.

Thus the late researches of experimental physiology explain for us the effects of heat and cold, regarded as toxic agents. The former is a poison of the muscular fibre, the latter a poison of the blood-globules. The case is the same with heat as with the other elements of the cosmic medium, in which the animated being lives. It enfolds the most contradictory powers, like the tender flower, spoken of by Friar Lawrence, in "Romeo and Juliet," from which may be distilled both safety and danger. It can by turns support health, heal disease, or inflict death.

Man is, then, the weak plaything of all those silent forces that surround and press upon him. In vain he enslaves them; he cannot escape the inflexible laws that subject the equilibrium of life to that of the lowest physico-chemical conditions. He has at least the consolation of knowing these laws, and guiding his existence so as to soften

their severity as far as possible. When Nature crushes him, she is unconscious of it, unconscious of herself: man, so small, is greater than these blind greatnesses, because his peculiar greatness is consciousness. The subject we have been studying is a grand proof of this; but its full, imposing interest would not be understood were we to end without giving the answer to the last question it suggests. Whence comes this heat developed by chemical phenomena in the living system? It comes from aliments which, in the last resort, are all drawn from plants, and they have borrowed it from the sun. When the vegetables, whose combustion takes place within the animal, there throw off a certain amount of potential energy, as heat, they do but transmit to it the force which the sun has supplied them with. It is, then, a portion of solar radiation, stored up at first by the plant, which the animal makes disposable and converts to use, whether for resisting cold or for securing the regular play of his motive functions. Thus we may say, with exact truth, the sun is the inexhaustible source, as it is the perpetual spring of life. From this point of view, science confirms the intuitions of oldest date, and man's poetic dreams in the childhood of the race. Reason completes the instructions of its long experience by harmonious agreement with the simple and natural sentiment felt by the first of men, when for the first time they looked on the splendor of day.—*Revue des Deux Mondes.*

NERVOUS HEALTH AND MORAL HEALTH.

AN able article in the *Times* some weeks ago on "Brain-work and Longevity," which has since been discussed and rediscussed in all sections of the press, was remarkable for several characteristics, especially for a curious thesis apparently indorsed by the *Lancet* of a subsequent week, that overwork of the brain, through late hours and the like, is a physiological impossibility. The argument was something of this kind: All brain-work means the destruction of nervous tissue or brain-tissue; all such tissue, when destroyed, must be repaired by food and sleep before it can be drawn upon again; therefore, overwork is impossible. A man may try to steal hours from sleep; but, if he does, he will only find how hopeless the attempt is the moment he passes the bounds of what the existing amount of tissue permits. He will struggle feebly against sleep, drop asleep, find he is doing no good, and be compelled, in the interests of his work, to shorten the hours of his work. The argument is full of fallacies, as any one might tell who applied a parallel argument to prove the impossibility of overwalking; and we are astonished at the sort of sanction given to it by the *Lancet*. It is quite as easy to prove that no man can overwalk himself. He cannot walk except by the destruction of muscular tissue, and, when as

much has been destroyed as makes him weary, he ought to drop down and go to sleep on the high-road, if the argument be worth much! As a matter of fact, of course, a man may destroy a great deal more of the supply of either brain or muscular tissue than he ought to destroy, before the process of reparation begins, just as he may live for days of comparative starvation on a great deal less food than he needs to keep his system in health, or even on the flesh he has made in past days. The brain-work done under such conditions may not be quite as sound, but yet it may draw a certain hectic fire from the glow of anxiety, which, to many a taste, would more than replace the defective soundness of thought. Indeed, the writer of the *Times* article admits anxiety as one of the causes of ill-health, through its effect in preventing sleep and proper nutrition; and why, if it prevents sleep, should it not prevent the sleepiness which alone prevents the destruction of more nervous tissue than is desirable at any one time? The writer is hardly consistent with himself; but we mention his argument, not for its own sake, but because his able paper represents the rise of a physiological school of ethics, which is, as we believe, gaining rapid ground and doing a great deal to supplant a true ethical doctrine. The real drift of all this skilful argument, partly indorsed by the *Lancet*, against the possibility of overworking the brain, is to strike a blow at the root of all ethics—the limited freedom of the human will. The physiologists want to identify moral action so completely with the physiological conditions of moral action, as to represent all life as the mere result of the growth and destruction of tissue, and as containing no provision for any real alternative choice at all. If a man can't overwork, as this writer says, but can very easily underwork, and can be overworried by any *involuntary* spring of care, the natural inference would seem to be that the secret of what looks like "*will*" in life is really not "will" at all, but some involuntary emotion which plays our actions as we play chessmen; and hence the rules of right action will have more and more to be sought in the manipulation of the influences to which our bodies and tastes are subjected, rather than in useless appeals to the will to do what the will has no power to do.

What would be the kind of ethics which would spring out of such a theory? We find traces of it in plenty of medical journals, and pretty distinct traces in the able paper on "Brain-work and Longevity" itself. "One who is insulted or offended," said the writer, "feels an instantaneous impulse to attack the offender. A mere brute, whether human or bestial, acts upon the impulse without reflection. A man may either act upon it after reflection, or restrain himself, and perhaps go peacefully away. If so, he will probably bang the door after him; *and will feel better for doing it.* A child or a woman will obtain the same relief from a gush of tears. In either case, the imprisoned force is discharged, is gone out from the system. Whatever may be the nature of an emotion, its repression is hurtful; but the repres-

sion of the depressing emotions is far more hurtful than that of the pleasurable. Grief, disappointment, or envy, when restrained from external display, has a marked tendency to exert a very hurtful influence upon the nervous system of organic life, which governs the processes of secretion and of repair." Now, if we take this doctrine along with the other, which denies to man all power over the physiological conditions of life, most men will infer that physiology is a far better source of guidance than any considerations of right and wrong. If the will has no power over the physiological conditions of life, while the physiological conditions of life have great power over the will, naturally we shall seek the guidance of the latter, and not try to find rules for the guidance of the former. Here, for instance, is a new rule of the physiological sort at once: "The suppression of all emotions, but especially of depressing emotions, is injurious." Therefore, in place of attempting to repress and conquer selfish anger by an inward effort, one ought, in deference to one's nervous physiology, to go and bang the door of some empty room at least, or indulge in a flood of tears with the women and children. Or, if envy—one of the most depressing of passions, as the exponent of the physiological rules for long life justly remarks—preys upon an ambitious or vain spirit, the depressing effect ought, we suppose, to be guarded against by inventing some similar safety-valve. If the sufferer rom that passion be literary or artistic, an anonymous satire or bitter caricature would become a personal duty, in order to avoid the injurious gnawing of a "depressing emotion." If there be no access to literature and art, to secure a confidant to whom backbiting speeches can be safely made, without danger of their being retailed, would not seem so much an ignoble indulgence as a medical precaution. Where is this doctrine, that the complete restraint of the "depressing emotions" is injurious to the nervous system, to lead us to, in the absence of any code of right and wrong that assumes the freedom of the will, and the power of obeying or infringing a divine moral law? It would suggest a perfectly new law of conduct, according to which we should shape our inward life, not with relation to any spiritual ideal within us, but in relation to the expediency of letting off dangerous physiological steam, by expressing whatever it might be injurious to repress. Quilp's device of keeping a wooden effigy, on which to let loose his evil passions, might become a serious suggestion in this physiological school of ethics; and what it might lead to in the direction of physical passion it is not even tolerable to contemplate.

Certainly there is one tenet of the Physiological school of ethics which is more and more frequently recommended to the world for its acceptance, not only by the apostles of these doctrines, but by the partisans of culture. Goethe was the first famous teacher who not only taught, but systematically acted upon, the teaching that men should deliberately turn away from all sources of disturbing emotion,

and keep their minds fixed on tranquillizing objects of contemplation. That was the physiological ethics arrived at from a different side—from that side of the mind which yearns after unshaken intellectual dignity, after calm self-possession. In other words, penitence for sin of any thorough kind should be carefully eschewed, for it involves strong emotion; and the inexhaustible craving after a perfection that cannot be attained should also be kept down, for that implies an inward gnawing of the heart which is dangerous to intellectual calm. Thus, what the physiologist reaches through the doctrine of "tissue," the apostle of culture reaches through the idolatry of intellectual calm. Does it need to be said that any genuine ethical doctrine, while it will listen to and not despise the lesson of physiology and the *cultus* of serenity, will regard both the one and the other as utterly subordinate considerations in relation to the moral ideal? As it may be right to lay down the life for others, so it may be right to endanger health, to draw too heavily on the supplies of nervous tissue, to face the possibility of a sacrifice of intellectual calm, in a word to run counter to the admonitions both of physiology and of culture. We should say, for instance, that to look any pain that naturally befalls us—intellectual, moral, or only of the heart—steadily in the face, and realize fully what it is and means, is one of the most imperative of inward duties, and that one is sensible of a certain unmanly cowardice in all the expedients for escaping from it by taking refuge in lower though perfectly innocent excitements, for hiding it away from one's self without learning all it means. And yet to grasp the full meaning of any real pain, whether due to one's own unexpected intellectual or moral shortcomings—whether it arises from shrinking of will, or failure of faculty, or the sin which brings remorse, or simply from the unfaithfulness of others, or from death—is one of the most "depressing" of the duties of the inward life, and one from which the natural man usually turns away without the need of warning from the physiologist. And if the comparative clearness of physiological science should ever lead to the substitution of a physiological for a truly moral code of conduct, we are quite sure that the very first result would be to render men less sincere with themselves, not only less able to govern themselves, but less willing even to face that which is painful or evil in their own natures. Nervous health is one thing, and moral health is another. We suspect that what is good for the one is often bad for the other, and that the doctrine which discourages the simple suppression of feelings that are beneath us, and the steady encounter with forms of inward pain from which Nature tempts us to escape, as a shying horse starts away from an object it dreads, is a doctrine which would sacrifice the highest part of man—that for which life is given—to the conservation of the tissues of the brain, and the cultivation of that coolness of temperament which is the best security for a somewhat ignoble longevity. —*London Spectator.*

BRAIN-WORK AND THE EMOTIONS.

AMONG the legitimate solaces of the toils of the modern biologist, there should certainly be reckoned the grim delight which he were less than human if he did not feel in terrifying Mrs. Grundy. Merely to hear a Huxley or a Spencer shout "Boh!" to a flock of the terrified orthodox is amusing, but to the man himself who makes it the fun must be even perilously fascinating. Doubtless, there is some danger of carrying the joke too far. One has heard of a philosopher, who, when courteously asked by a company of the most intelligent of the London clergy to explain some of the principal points of conflict between scientific data and conventional religious theory, began his speech by bluntly telling his audience that he was going to relate important facts, but that his hearers were such unimportant people that he did not care a button whether they believed the facts or not. Such rudeness gives even more pain to the truly scientific mind than it inflicts upon the immediate sufferers.

However, there really is legitimate amusement to be had, and even much good to be done, by the biologist, in shocking the theoretical prejudices of the metaphysicians. The irony of Von Hutten, and the delicate wit of Erasmus, when exposing the intellectual contemptibility of the opponents of the Reformation, were not more truly helpful to the progress of humanity, than are the assaults of those physiologists and physicists who are even now smashing the crockeryware of the metaphysicians and kicking the fragments about with a fury that one can easily see is partly fun. As for that large section of the clergy who persist in looking at the phenomena of mind only through the spectacles of Hamilton and Mansel, there really is no way of dealing with them at all except that of pelting them with incessant ridicule. It is inexpressibly comical, and yet provoking, to hear them keep chattering about the tendency of modern biology to degrade our ideas respecting mind; for one has only to look back some fifty or sixty years to remember the days when mind was considered exclusively the domain of theologians and metaphysicians, and mental diseases were treated according to "high priori" notions instead of medical science. One would think that the cruel and shameful failure of that old system, and the striking benefits that at once accrued to the mentally afflicted when physicians boldly declared that the mind could only be successfully treated by treating the brain—one would think that these and many other similar things would have taught the metaphysicians modesty; but such is not the case. It was but four years since that the Archbishop of York delivered himself of a most presumptuous and densely ignorant attack on modern biological speculation, and was promptly castigated by Dr. Maudsley. To this day,

the typical clergyman—we do not speak of such exceptionally liberal men as one often meets in London—holds as firmly as ever to the belief that all discussions of moral perversion, which deal with it from the side of mere bodily organization and health, are an insult to religion—a lapse into the black gulf of what he calls "materialism."

It is not with such persons, however, that we are now concerned; but rather with a class of writers, truly liberal and full of culture, who, nevertheless, cannot get over what seems to them the hopeless divergence between recent physiological doctrines and any systematic teaching of the "higher ethics." To this estimable class belongs the writer of a thoughtful article in the *Spectator*, on "Nervous Health and Moral Health." His text is the recent discussion originated by a remarkable leader in the *Times*, which declared that brain-*work* does not kill, but that brain-*worry*—especially stifled emotion—is the really fatal agent in nearly all cases where overwork gets credited with a death. Let us repeat here that the experience of medical men undoubtedly shows that this is no fancy, but (with comparatively trifling exceptions) an important general fact. The *Spectator* does not venture to deny this statement altogether, but, accepting it provisionally as correct, argues that such teaching would lead to dangerous results, unless we acknowledged that what is good merely for nervous health *may* be bad for moral health, and *vice versa*. We certainly cannot admit this, and we believe that the fears of the *Spectator* as to modern physiology leading to bad ethics are quite groundless.

To the writer in the *Spectator* the danger seems to be that medical philosophers are proposing to extinguish human emotion, and reduce all men to a dead level of intelligent but selfish complacency, reaching the same point, for the sake of preserving health, as Goethe aimed at for the sake of preserving perfect artistic culture—or "sweetness and light," as Mr. Matthew Arnold would call it. We cannot, of course, stand sponsors for the original writer in the *Times;* but we cannot see that this was what he intended to say; and, at any rate, this is not the voice of modern physiology as we understand it. What the physiological psychologists do affirm is this: That, whereas serious and calm intellectual work is only very slowly destructive to the nervous health, emotion, *unless directed into proper channels*, is highly destructive to the stability of the nervous system. And they further say that the conventional ideas as to the propriety and utility of certain kinds of emotional excitement do visibly bear, in the experience of medical men, the very worst fruit possible. They do not say, as the *Spectator* hints, that the emotion of repentance for *real guilt* is a thing to be shunned; but they declare that the habit of self-torturing introspection, which the clergy and teachers are especially earnest in recommending as a means of spiritual purification, is so far from promoting the existence of a really high and pure standard of ethics, that it ruins both body and soul, in the majority of cases, wherever it

is applied on the large scale. More especially they believe that the habit of inducing unnecessary emotional excitement, in young persons who are just entering the dangerous period of commencing sexual life, is so morally and physically injurious to a large number of individuals, that it may well be questioned whether those individuals might not have been more safely left in total neglect and ignorance. We suspect the writer in the *Spectator* little knows—for no one but a medical man can know—the terribly doubly-edged character of all those more powerful emotions which he believes are so exalting in their effects upon the spiritual nature. Here and there, it is true, we do find some one of such stern Roman nature that he can take a torturing emotion into the recesses of his heart, and discipline himself by the pain which its repression causes, and by that pain alone. But, for the common race of man, it seems to be the duty of the physiologist to insist—first, that the immature and tender system of the young should never be exposed to the influence of any avoidable emotion, unless it be such as can be freely and harmlessly expressed, and in particular that self-invented spiritual tortures should be absolutely interdicted; and secondly, that older persons, who must be exposed to disturbing emotions, should at least be encouraged by all means to balance painful with pleasing and refining feelings, and, above all, to have confidence in the really soothing and strengthening character of regular fairly strenuous intellectual work, and the favorable influence which is exerted, even upon moral character, by the substitution of productive labor for the fluctuations of sterile excitement.—*London Lancet.*

THE ROMANCE OF MEDICINE.

By FREDERICK ARNOLD.

IN once more gathering up the threads of this subject from other years, and endeavoring to address a lay audience from a laic point of view, one would naturally desire, according to the limited measure of one's ability, to grasp some medical subject for which we all have an affinity, and which may be of usefulness to some. But in these papers I enter into an implied bargain with my readers to tell them something picturesque and odd—something that may even be romantic and sensational: but I am also troubled with the uneasy idea that I might ventilate some matters that might be for the health and happiness of some of us. I am like some honest citizen who has only got some modest extent of garden-plot, which he feels bound to lay out with flowers, but at the same time he has some yearnings toward homely but esculent vegetables; or, to vary the simile, just as mathematicians have their pure and applied mathematics, so in discussing

questions of medical life and science, one desires not only to look at the subject on its abstract and literary side, but to aim at some concrete good. I will propose, *lector benevole*, that we attempt a compromise; that while, in random, discursive talk, I am permitted, as heretofore, to cull some anecdotes, thoughts, and illustrations, such as outsiders may care to gather from a particular science, I may yet dwell on matters that may be of essential home interest to us, and hope there may be a somewhat serious design and meaning underlying our *olla podrida*.

In Medicine, the first object of interest and attention is the medical man himself. An author is to me something more interesting than any thing he does in authorship; a great classic's works are only the fossil remains of a vanished world of intelligence. When patients ponder on pills and potions, I the rather wonder why they do not examine into the nature and idiosyncrasy of their medical man. They may depend upon it that, if he is worth much, he will be examining into *their* nature and idiosyncrasy. The great question for the patient to solve is, whether his doctor has got the mystic gift. He may be chuckful of science; tap him anywhere, and there will be a clear-running stream of fact and comment; but the practical question is, whether he will prove a healer to me. High science may leave a man very stupid for practice. The knowledge of things is but an adjunct to the knowledge of ends. The physician, aware, in the first instance, of all the dangers his patient is liable to, should, then, from his own knowledge, select the best means of obviating them; but, though he had the whole *materia medica* by heart, he would not be nearer his mark if he knew nothing of disease; and this is essentially the full-gotten knowledge of good and evil impressed on him through a susceptibility of his mind altogether distinct from the acquisition of natural history and chemistry. To remember well the pains and the moments of relief of all the sufferers he has witnessed is the first requisite of a physician; to couple these with their attendant circumstances, and to store them up too, is a further extension of the practical intelligence. On this foundation he ought to build a store of Nature-knowledge, of book-knowledge, and of logical acumen. As a man, prudent for himself, should remember adequately all his own pains, so a man, skilfully prudent for the sick, should remember all their pains and weaknesses in the first instance; his head should be more full of misery than the box of Pandora, and his only solace should be the hope at the bottom. This is a wise set of sentences, which I have found stored up among my medical notes and reflections, and, I believe, goes pretty deep into the heart of things medical.

If a medical man shows at great advantage in your home or in his own, there is one place in which he is too often uncomfortable, and makes other people uncomfortable as well. This is the witness-box. There is hardly any great trial for murder, but doctors and counsel

come into fierce collision; there is the conflict of medical testimony, and the common-sense of judge and jury is frequently insulted. It would be a golden rule for a medical man never to use a scientific term if a popular term would serve his use as well. The medical man not only states facts, but obtrudes his explanations and theories about them, and does so in highly technical language. The legal mind revolts against the assumption of the medical mind, and in this way much prejudice is done to science. The lawyers are pretty unanimous in holding that a medical man is the worst possible witness. He cannot plead privilege, like the lawyer or the confessor, and his best plan is to tell his story at once, in the most intelligible and straightforward way that he can. The eminent German physician, Caspar, who for many years was forensic physician to the Berlin justiciary courts, is very severe upon medical witnesses: "How often have I heard physicians talking to the judge and jury of 'excited sensibility,' 'reflex movements,' 'coma,' 'idiopathic,' etc., without for one minute considering that they were using words and expressions wholly unintelligible to unprofessional parties!" Caspar's work is a perfect *thesaurus* of odd incidents and cases; and, if read, it ought to be compared with Taylor's "Medical Jurisprudence," that we may compare the difference between the English and the Prussian systems. The Prussian plan of having an accredited medical officer attached to a court, who in some sort of way is a minister of justice, is certainly an improvement on a scene not infrequently witnessed in English courts, where a criminal trial is turned into an arena for the conflict of scientific testimony.

If you take the volumes of Caspar, and Prof. Taylor's book, and throw in a little more sparkling literature, like "Christison on Poisons"—Christison, like the Fat Boy, will make your flesh creep—you will have the materials—a veritable huge quarry—out of which you may hammer all kinds of sensational and romantic stories. You may read up the murderers, just as old Boffin read up the misers. There is the eccentric Miss Blandy, of Oxfordshire, who poisoned her father as a means for promoting her matrimonial projects; the highly luxurious and wealthy people who have tried to poison, not with vulgar lead and arsenic, but with silver and gold; the aberrant wife who poured poison down her husband's open mouth as he was sleeping. Then there are cases where a three-volume plot might easily be elaborated—where a man or woman had actually taken poison, and secreted poison about the effects of an innocent person, that suspicion and punishment might be directed toward the innocent person. These are cases out of Christison. That learned professor gives a word of caution against a practice that has received considerable laudation. Some preparation of antimony "is often foolishly used, in the way of amusement, to cause sickness and purging, and likewise to detect servants who are suspected of making free with their mistress's tea-box or whiskey-bottle; and in both of these ways alarming effects have sometimes been produced."

It is curious to see the race between sin and science: how the tests of the chemist even more than keep up with the craft of the murderer. Some of our most celebrated poisons are of comparatively recent date. Prussic acid was discovered, not so very many years ago, by Scheele—though poisoning by cherry-laurel was a well-known process; and the late Mr. Palmer, of Rugeley, first brought strychnine into such felonious popularity. The toxicologists can count up their martyrs to science. It is curious to observe how each advancing wave of time blots out the records of crime. The crime that was a national event becomes a tradition—is lost in a black abyss of forgetfulness. There, so far as we are concerned, let such traditions rest.

We come back, however, to the point of departure whence we digressed. The culture of the medical man is also combined with a very large experience of life in its broadest bearings and its intensest moments. The education, instead of being confined to a single school, has very commonly been carried on at several great medical centres. Travel is more than ever becoming one of the marks of a highly-trained medical man. There is a period of leisure for nearly every medical man, which, rightly used, may be one of unspeakable preciousness and importance for him. This is the time that lies between the call to a profession and the obtaining any large share of work. As a rule, all preparatory studies have not done more than to break up the ground, and prepare it for the fertilizing process. The real work is to be done when the mind is released from tutors and governors, and can concentrate itself on the thought and work of maturer years. Travel is the opportunity that best enables a man to combine study, thought, and observation. It is astonishing what a large and increasing space is occupied in medical life by travel. It is now not at all uncommon for English medical students to spend a great deal of time at the medical schools of Paris and Vienna. They generally prefer Paris to Vienna, and London to either. The best medical men more than ever seem to be familiarized with the scientific medical thought of Germany. The custom of going out as medical officer to vessels is very largely on the increase. Many young men go with the steamers that traverse the regular ocean thoroughfares. Men who have risen to, or descended from, eminence have been glad to take positions on the great lines of steamers. They are found a most agreeable addition to all the social arrangements—with the drawback, however, of being obliged to subsist in a chronic state of flirtation. Others take longer voyages, and, generally speaking, seek a more adventurous line of life. Thus there are, among men I have known, those who have gone to the Greenland seas, round Cape Horn, to Australia, to India, and the Pacific islands, and have gone, again and again, induced by the divine passion for knowledge and travel. There would be many competitors for the place of medical officer to travel with some of the expeditions that nowadays go round the world. What such travel might be can be

seen, with admiring despair, in Darwin's "Voyage of the Beagle." Then many people, when they travel, are neither easy nor happy unless they can afford the luxury of a "medical attendant." Some of the best specimens of medical literature that we have are due to this interesting class of medical men. A Milor on his travels likes a parson, a doctor, and a traveller's major-domo; but the doctor is least easily dispensed with. In this way, by the medical education abroad, by travelling engagements, and by taking appointments on board ship, we have a travelled class of medical men who represent, perhaps, the most interesting, and certainly the most amusing, section of the profession. Wherever in this wide world the medical man goes, he can carry his work with him and his own letter of introduction. The wants which surgery and medicine relieve speak their own vehement, universal language, and stand in need of no interpreter. The lawyer can do no good with his law when once he is out of England. The clergyman must learn the language of the natives, and find his opportunity and his audience. But the medical man speaks the universal language, inasmuch as he answers a universal need. The philosopher and the parson can never be quite sure that they have done any good; the good is so remote and hidden, and it rarely happens that it is ascertained. But the surgeon goes to a man in a state of positive torture, and by a happy bit of carpentering puts him to rights, gives the intense happiness of a sudden cessation from intense pain, and at once earns a thrilling amount of very transitory gratitude. It would be only reciting truisms to speak of the immense generous good they achieve. The amount of self-denying generosity which a physician can practise, and does, is simply incalculable, and there are, indeed, few of us who could not easily furnish a collection of instances.

The curiosities of medical life and practice are endless. If we hear very often of medical men doing arduous work for very scanty remuneration, sometimes there is an agreeable obverse of receiving very splendid remuneration for very scanty services. We know of a medical man whose duty it is to take lunch every day at a great castle belonging to a noble lord. The household is immense; and there is just the chance that there may be some case of indisposition demanding attention. He gets some of the best company and best lunches in England, and duly charges a guinea for each attendance. There is a very wealthy man near a great city, who cannot bear to be left for the night. There is a physician of great ability who drives out of town nightly to sleep at his residence; he is consequently debarred evening society, and if he goes out to dinner he has to leave his friends before wine. He has to charge his patient a thousand a year; and, I think, he works hard for his money. Sometimes the services are such that money cannot repay them. A friend of mine, a young medicus, had a standing engagement of four hundred a year to look after the health of an old lady. She required to be inspected three times a day, and

make an exhibition of tongue and pulse. What made matters so aggravating was, that she was as strong as a horse, while the doctor was a delicate man. She was so selfish and perverse, that he was obliged to tell her that he would have nothing to do with her case. Similarly, I have known the son of a rich man who proposed to pay a clergyman several hundred pounds a year for leave to spend his evenings with him. The parson, however, was obliged to tell his rich friend that he talked such intolerable twaddle, that he could not accept his company on any terms that could be named! But the oddest of these arrangements is the following: A medical man has been attending a patient several years, and yet he has never seen his patient. The gentleman firmly believes that he has an œsophagus of peculiar construction, and that he is accordingly liable at any moment to be choked. That help may be at hand whenever any sudden emergency may occur, he has a physician in the house night and day. The physician, being human, must needs take his walks abroad, and it becomes necessary to provide a substitute for him two hours a day. Accordingly a doctor attends daily from twelve to two, fills up his time by disposing of an admirable lunch, and finds the gold and silver coin, in their usual happy combination, neatly put by the side of his plate, in tissue-paper. Up to the present date he has never had the pleasure of exchanging words with his interesting patient.

It is in medical biography, or, rather, medical autobiography, that we must look for our most valuable and authentic instances. Medical literature is not rich in this way; some half-dozen volumes would nearly include the whole. It is to be regretted, indeed, that the best medical men write the least; those who have obtained the highest rank in their profession, and who would have most of science, most of incident to impart. There is all the difference in the world between books that are written to obtain practice, and books that are written out of the fulness of practice. . . . In medical autobiography we have such charming narratives as those written by Sir Benjamin Brodie and Sir Henry Holland. There is no doubt that even fictitious narratives, such as "Early Struggles," in the "Diary of a Late Physician," really give us facts substantially as true as any which we find in regular memoirs. I myself know physicians of singular learning and ability, who for half a dozen years have not taken half a dozen guineas a year. Other men, by the happy use of dress and address, though inferior, leave them far behind. One instance is on record which might well be worked up into some narrative like Mr. Warren's. An able man waited and waited hopelessly till ruin stared him in the face. One night, when brooding on his miseries, he heard a bell ringing violently at his surgery door. Opening it, he found that a man had been thrown out of his cab and nearly killed, and they wanted to bring him into the surgery. The medical man found that there were concussion of the brain and dislocation of the shoulder-joint. His card-case showed that

he was a man of birth and a well-known politician. He stopped some time at the surgeon's house, who was thus enabled to lay the foundation of a large and lucrative connection.

Dr. Denman, the father of the great Lord Chief Justice, and the grandfather of our new judge, who has so worthily been promoted to the bench, which he will adorn, prefixed an autobiographical narrative to his "Introduction to the Practice of Midwifery." He was educated at the Free School at Bakewell, and, going up to London to study at St. George's Hospital, he boarded and lodged with a hair-dresser at half a guinea a week. In six months his money was gone, and he thought, as a desperate chance, he might get a surgeon's appointment on a king's ship. To his great astonishment, he passed, but he had to pawn his watch before he could join his ship. Once he tried to set up a practice, but he was obliged to betake himself to the royal navy again. However, he tried again. "I had taken a small house in Oxendon Street; but I furnished only one parlor, thinking to complete it gradually as I was able, and I hired a maid-servant, who cheated me very much. When I went into this house, excepting my furniture, I had but twenty-four shillings in the world, but I was out of debt." He got on gradually, made a very happy marriage, bought houses, bought land, kept his coach, and, what, as a Bakewell man, pleased him immensely, he was called in to attend the Duchess of Devonshire. "I was made happy," he writes, "by the birth of a son, which was an unexpected blessing, as I had given up all hopes of having any more children." This son was the celebrated Lord Chief Justice. In time, Dr. Denman became the head of his profession.

Many similar instances might be supplied. Even John Hunter had to make his way amid the greatest difficulties, having to satisfy his brother William of his genius before he could satisfy the outside world. Sir James Simpson is another instance of a man who might have taken *nitor in adversum* as his motto. He was one of the poorest of poor students who flock to a Scottish university. There is a pretty little village called Inverkip on the Frith of Clyde, near which is Sir Michael Shaw Stewart's great place. He applied for the office of village surgeon, but, not having any local influence, the appointment was refused him. Sir James used to say that he felt a deeper amount of chagrin and disappointment from this circumstance than from any other event in his life. Going before a famous pathologist for examination, the examiner was so pleased with him that he asked him to become his assistant. When Simpson became a candidate for the chair of Midwifery at Edinburgh, the great local interests were again enlisted against him. It was alleged that his election would be prejudicial to the interests of hotel-keepers and city tradesmen, for it was not likely that many strangers would be induced to visit Edinburgh for the purpose of getting professional advice. It was not for the first time that the highest intellectual interests had been imperilled at Edinburgh by

such petty considerations. As a matter of fact, no physician ever attracted such a number of visitors; the invalids came in shoals. Simpson once told his pupils that many of his best papers were written by the bedsides of his patients. His great principle, when he met with any apparently hopeless case, was to interrogate what Nature did in the rare instances in which she effected cures. Simpson's great discoveries may be here enumerated; they form the most thrilling page of modern medical history. His first great achievement was that he procured chloroform undiluted, and discovered the effects of the vapor. This great discovery alone would suffice to associate his name with that of Harvey. That night of the 28th of November, 1847, is much to be remembered, when this great discovery was made. He then demonstrated the possibility of banishing pain and subjecting it to human control. There are now a great many manufactories of chloroform in Edinburgh alone—one that makes several million doses a year. His great surgical invention is acupressure—stopping blood from cut arteries by the use of metallic needles. His third great achievement was his contributions to that great work in which Dr. William Budd has preëminently labored. This is to endeavor to *stamp out* contagious diseases as completely as the poleaxe could exterminate the rinderpest. His last great work was in the direction of hospital reform. How was it, he asked, that, in the hospital, the mortality in cases of amputation was one in 30, and elsewhere one in 180? Hospitalism has its special evils, that are fatal in these palaces of human suffering. Sir James Simpson's final suggestion goes to the root of the matter—that all staircases, etc., should be outside the building, and that no one ward should ever have even the slightest chink of communication with another.

This last reform of Sir James Simpson's is especially important. It is not too much to say that all the great triumphs of surgery, such as those in lithotrity and ovariotomy, have been practically neutralized by foul hospital air, to which is due one-half of the deaths in our great metropolitan hospitals. In surgical wards there is a condensation of foul air, and, in addition, the specific poisonous effluvia given off by foul air. Mr. Spencer Wells is famous for that wonderful operation by which the lingering agony of years is prevented by the knife being used under anæsthetics. He generally uses the new anæsthetic methylene, which, in many cases, is preferable to chloroform. He found that there was a large mortality in hospitals, which was reduced to one-eighth in private practice. St. George's Hospital has now a small institution for ovariotomy at Wimbledon, an example which may be extensively followed. It is to be hoped that in the magnificent sea-side institutions that are so much increasing among us there will be a conspicuous adherence to the principle of the cottage hospital. The National Hospital at Ventnor is constructed on the cottage principle, and we have before had occasion in these pages to testify to its wonderful efficiency.

A case, which, some time ago, was tried in the Court of Queen's Bench, illustrates, in a striking manner, some of the dangers that belong to the annual national migration to the sea-side, and also suggests some very large and important considerations affecting the national health. Without going fully into the details of a peculiarly painful case, it will be sufficient to mention the salient facts. Sea-air having been ordered for a child by a medical man after an attack of scarlatina, a lady took her nurse, governess, and children, to the coast, and hired apartments without telling the lodging-house keeper of the nature of the illness in her family. After a time this most infectious of all infectious diseases broke out afresh, apparently from the neglect of the proper disinfecting processes, and the poor lady lost two of her children, and the unhappy landlady of the lodging-house also lost two little ones. The anguish of parental grief cannot be measured by a pecuniary standard, but actual medical and funeral expenses, and the injury done to the course of business, are susceptible of being assessed, and the jury gave the lodging-house keeper substantial damages. It is impossible not to feel commiseration for the sea-side visitors who experienced this blow in addition to their own calamities, but the verdict was not unwarranted by the facts, nor, to use regretfully a harsh word, undeserved. Those who are acquainted with the history of special classes among the poor are aware how much deadly illness there has been at times in the families of laundresses and pawnbrokers, who have had under their charge the raiment of fever-patients, to which no purifying process had been applied. (Still greater mischief has been done by milk which has been adulterated with water taken from some impure source.) We know, also, of cases where lodgings or furnished houses have been let, in the holiday season of the year, after the occurrence of contagious illness, and yet no disinfectants have been used, and no honest warning has been given. It must increasingly be felt how necessary are some caution and judgment in making holiday arrangements. It is comparatively easy for a lodging-house keeper to recover damages from a well-to-do family in a case where fever has been propagated through a want of care and candor; but, if the converse case had occurred—and it happens in at least an equal degree—it is hardly likely that substantial damages could be obtained from the landlord, even if bereaved fathers, in their grief, should be inclined to seek them. Scarlet fever slays in this country annually some twenty thousand people, and disables, more or less, for a longer or shorter time, a hundred thousand more. Yet, humanly speaking, the larger amount of this mortality might be averted by the processes of disinfection, separation, and, we may add, a religious adherence to truth.

It is not pleasant to think of the successive steps in the history of the sad case to which we have alluded, yet they illustrate the dangers of the travelling public, and might explain the apparently mysterious origin of many a similar attack. The mischief arose with a conva-

lescent patient going to the sea-side. We easily picture him going to the terminus in a London cab, travelling in a public railway-carriage, then travelling in another public conveyance, and finally deposited in a public lodging-house. Early convalescence is often a most dangerous period in the disorder, when minute particles from the skin—invisible, impalpable—take wings, and become elements of danger, multiplying seeds of disease and death. It is safer to travel in a carriage with parcels of nitro-glycerine than with such a patient. If our national sanitary arrangements were in a satisfactory state, such a case would be certified from the London to the local physician, and, both on road and rail, special carriages would be provided, or the ordinary carriages be at once disinfected. Or if, as is usual in this country, such things must be left in private hands, there is a proper treatment which would entirely, or almost entirely, annihilate the danger of contagion. Many of our readers will recollect the piteous case set forth some time back by Dr. Bradley, the present head of University College, when he was head master of Marlborough College. He wanted to know, in the columns of the *Times*, and various afflicted parents made the same inquiry, when it would be safe for a boy recovering from scarlet fever to return to his home. Scarlatina is almost the one terrible rock ahead which public and private schools have to fear. Many of us know very sad stories of the premature deaths of the young, and the losses and even ruin of school-masters through this terrible visitation. It is not every school which has the vitality of Marlborough College to withstand such trials. In answer to these appeals, the whole theory and practice of disinfection were clearly set forth by competent medical authority. Such obvious methods were suggested as the isolating the patient, the anointing him from head to foot with camphorated olive-oil, the destruction or most thorough cleansing of all things infected, the use of entirely untainted clothes; and then we are assured that patients might be restored to society after a very limited quarantine. The natural apprehension would be that these simple means might not prove sufficient; but the real fact is, that it is extremely difficult to make people resort even to such simple means as these. Not one hundredth part is found of the energy in preventing disease that is employed in attempting to work its cure. What is wanted is a wider teaching of the elementary principles of such matters, and a greater degree of courage and conscience in applying them.

The fact is, that the prevention of diseases should be more regarded than it is, as a true end and scope of medical science. It is to the credit of medical men that they are more and more devoting their best energies in this direction. The skill of medical diagnosis has been carried to the utmost, but not with the result of any corresponding subjugation of disease. Indeed, it is a humiliating fact that, in those chest-cases where medical science has made the most marvellous dis-

coveries, the actual amount of disease is probably greater than ever it was. The doctors are even quarrelling among themselves, whether certain illnesses are contagious or non-contagious. There is no doubt that scarlatina is contagious; but, at the time of the illness of the Prince of Wales, it was sharply debated whether typhoid fever was infectious or not. Even the fact of such a discussion is hardly creditable, for it might have been thought that scientific men, by a scientific induction of facts, could have set such a question at rest by this time. But we feel quite certain, especially in days when people travel and sojourn away from home, that no case of illness should be found to exist which any opinion entitled to respect should consider infectious, but it should be surrounded with safeguards, and so be saved from becoming the source of those terrible domestic tragedies with which we are all so unhappily familiar.

We have now brought our readers to a point to which we have been working up in the course of this paper, a point of extreme practical importance and urgency, on which the opinions of the public and their suffrages should be collected. We wish to draw more particular attention to a subject which we have just lightly touched on, one which we believe cannot be too much ventilated and discussed among general readers, and on which they are qualified to form an opinion, and to take action upon it. The theory involved is extremely simple and interesting, albeit strictly scientific; but the practical importance of it is enormous. Somewhere in the dim perspective many of us can discern the promise of a golden age, when all curable accidents will be cured, and all preventible diseases will be prevented. There can be no doubt but a simple contagious disease is susceptible of being stamped out. We stamped out the cattle-plague, and, if the plagues of men touched the same obvious and immediate pecuniary interests as the plagues of cattle, we might stamp out similar calamities among human beings. To a certain extent the history of the small-pox shows how much can be done this way. In the remarks we are about to make we most especially acknowledge our obligations to Dr. William Budd's writings and teachings on the subject, who has developed his views, full of import to the happiness and well-being of humanity, with immense ability and experience, and much literary skill. The theory is, that any contagious disease can be eradicated; or, at all events, limited within a very slender area; and that various diseases are in reality contagious, such as typhoid fever and consumption, where the ordinary medical and general mind does not admit the fact of the contagiousness. If we resort to the primitive processes of counting noses, or listening for the largest amount of shouting, we shall decide against the theory; but at present legitimate argument and logical deduction appear to be in its favor.

Mr. Disraeli's policy was lately denounced as a policy of sewage. What has been called by some a policy of sewage, has been more

properly called by others a question of life and death. We do not mind Mr. Disraeli and his friends having a policy of sewage, but it is essential that the policy should be accurate and enlightened. The advocates of the contagion theory have no weakness for sewage, especially in an olfactory point of view. They say, also, that it places disease under the most favorable conditions for the consummation of its evil mission. But they assert, in opposition to former theories of the Board of Health—that has an unlimited command of print and pay—that sewage, in itself, does not breed fever and infection, unless it is charged with specific ingredients of contamination. Infectious diseases are only communicated by the virus of specific poison. Many of us, in the course of the holiday season of the year, accumulate a collection of instances on the subject. In the famous cities of the Continent, and in exquisite Swiss villages, we have the most noisome stinks and sights, yet we hear nothing of fever. In fact, it almost seems a rule that, where Heaven throws the greatest beauty and magnificence, man should exhibit the greatest abominations. Natural beauty goes, like King Cophetua's beggar-maid, in rags. Clovelly, in Devonshire, is the most romantic spot we know in the western land, and, till recently, it was the most undisguisedly dirty. But all through the west of England, and, indeed, we are afraid, all over the three kingdoms, we shall find lovely villages that, despite their loveliness, will give the utmost offence to sight and smell. Yet, for whole decades of years, no infectious illness is heard of in these villages; and then, suddenly, fever or small-pox breaks out, and, to say the least of it, simply decimates the humble inhabitants. The contagionists will assert that the evil state of things was comparatively harmless until charged with a specific virus. One fact bearing on the subject will be fresh in the recollection of all readers. Many years ago, the Thames began to stink horribly in the hot months. The law courts broke up, the Houses of Parliament were saturated with chloride of lime, the river steamers lost their traffic, and business-men went miles out of their way, in order to avoid crossing a city bridge. "India is in revolt, and the Thames stinks," were the two national humiliations bracketed by our severe friend "the intelligent foreigner." It so happened, also, that a Thames waterman died of the cholera; and that unfortunate waterman created the utmost consternation in the country. A frightful outbreak of cholera and fever was expected. But nothing of the kind happened. The health of the metropolis was remarkably good; the death-rate below the average, especially in the diseases supposed to result from poisonous emanations. There was certainly a failure in the supposed connection between epidemics and a bad sanitary state of things; and the suggestion arises that we were mercifully saved the introduction of some element that might have wrought all the misery we dreaded.

When the Prince of Wales was ill, we all of us, unhappily, ac-

quired some kind of notion on the subject of typhoid fever. Each morning paper became a kind of daily *Lancet*. It is not much to the credit of the medical profession that there has been a great deal of confusion between typhus and typhoid. The latter, from which our prince suffered, is totally distinct from typhus, and has its own distinctive marks, as much as small-pox itself. An eminent physician suggests that it should be called the *pythogenetic* fever, which is, however, begging the question at issue, which is the great medical problem of our time, whether this disease is the result of malaria or of contagion. Dr. Budd argues that as it is in typhoid fever, so it is in small-pox; as it is in small-pox, so it is in measles; as it is in measles, so it is in scarlatina; as it is in scarlatina, so it is in malignant cholera: amid all varying phenomena, *one thing constant, a specific morbid cause*, "a cause which is neither a permanent product of the soil, nor of the air, nor of particular seasons, but which is susceptible of transmission from place to place; which breeds as it goes, and then again dies out, or becomes dormant, without leaving any sign to mark its track."

The slaughter of the Franco-Germanic War is repeated year by year in England by preventible diseases. This enormous mass of disease furnishes ample material for infection on every side. A most infinitesimal germ, invisible, impalpable, would suffice to infect a single human body, and that body might suffice to infect very many others. It may be said that the link of connection is not always sufficiently clear between the infector and the *infectee*. In a vast proportion of cases this is clear enough, and it is no argument where it is not. People have been taken ill of small-pox even in prison, under solitary confinement; yet how could we doubt of real though remote infection? Let each individual do his part in the holy crusade against ignorance and disease. Let it be asked, amid contemplated legislation, whether the state cannot give effectual hope. We may then hope to transmit to our children their heritage of earth and time less stained by scalding tears and passions of regret than it has been to us and to our fathers.—*London Society.*

THE EXPRESSION OF THE EMOTIONS.

WHATEVER may be the ultimate verdict as to the truth of those views which are associated with the name of Darwin, it certainly cannot be denied that Mr. Darwin himself has a profound belief in them. The work which he has just published, under the title "On the Expression of the Emotions in Man and Animals," is a new test to which he subjects his own doctrines. He considers the subject from the point of view of evolution, and, though many may consider

that he is far from having established his case, it will be admitted by every reader that he has thrown much new light upon it, and made a most fascinating and instructive book. Mr. Darwin distinguishes between physiognomy and expression. The former is statical, the latter dynamical. Physiognomy aims at the recognition of character through the study of the permanent form of the features. Expression, on the other hand, deals with actions, or the play of features and gesture in man and animals, as constituting the natural language of the feelings. Much has been written upon the subject of Expression by men of various countries, but Mr. Darwin recognizes that Sir Charles Bell, in his "Anatomy and Philosophy of Expression," published in 1806, not only laid the foundations of the subject as a branch of science, but built it up into a noble structure. Mr. Darwin is of opinion that the subject has hitherto been pursued by a false method, or has been vitiated in its treatment by erroneous assumptions. Bell, Gratiolet, Duchenne, and the other leading writers upon the question, have dealt with it on the old hypothesis, that the different animal species came into existence just as they are now, wholly distinct from each other; but Mr. Darwin maintains that, so long as man and all other animals are viewed in this way as independent creations, the true philosophy of the subject cannot be reached. The simple before the complex; the lower forms of life as interpreting the higher, and the whole as a connected scheme of development, is now the method of biology, and for this investigation it is, therefore, necessary to study the manifestations of character in their simplest forms.

An able writer in the *Saturday Review* summarizes Mr. Darwin's views as follows: "The tendency to draw as broadly as possible the distinction between man and brutes led Sir Charles Bell to deny to the lower animals any expression beyond what might be referred more or less plainly to acts of volition or necessary instincts, their faces seeming to him to be chiefly capable of expressing merely rage or fear. The facial muscles in man he thought to be a special provision for the sole object of expression, and so far distinctive of humanity. But the simple fact that the anthropoid apes possess the same facial muscles that we do, renders it most improbable, apart from any reference to teleology in general, that we were endowed with these muscles for any such purpose, still more that monkeys had special muscles given to them solely for the purpose of exhibiting their hideous grimaces. Since distinct uses can, with much probability, be assigned to almost all the facial muscles, we may look upon expression as but an incidental result of muscular or organic function. Mr. Darwin's early inclination toward the doctrine of evolution, or the origin of man from lower forms, led him five-and-twenty years ago to regard the habit of expressing our feelings by certain movements, innate as it has now become, as having been in some manner gradually acquired at the first. Seeking back for the origin of movements of this kind, he, in the first place, was

led to observe infants, as exhibiting emotions with extraordinary force, as well as with a simplicity and an absence of convention which cease with more mature years. Secondly, the insane had to be studied, being liable to the strongest passions, and giving them uncontrolled vent. Dr. Duchenne's ingenious application of photography, representing the effects of galvanism upon the facial muscles of an old man, gave some assistance toward distinguishing varieties of expression. Less aid than was expected was found to be derived from the study of the great masters in painting and sculpture; beauty in works of art excluding the display of strong facial muscles, and the story of the composition being generally told by accessories skilfully introduced. More important it was to ascertain how far the same expressions and gestures prevail among all races of mankind, especially among those who have associated but little with Europeans. With this view a list of 16 questions was circulated by Mr. Darwin within the last five years, to which 36 answers have been received from missionaries, travellers, and other observers of aboriginal tribes, whose names are appended to Mr. Darwin's introductory remarks. The evidence thus accumulated has been supplemented by the close and keen observation of the author himself through a wide range of animal life. It seemed to him of paramount importance to bestow all the attention possible upon the expression of the several passions in various animals, not, of course, as deciding how far in man certain expressions are characteristic of certain states of mind; but as affording the safest basis for generalization on the causes or the origin of the various movements of expression. In observing animals we are not so likely to be biassed by our imagination, and we may feel sure that their expressions are not conventional.

"As the result of his observations, Mr. Darwin has arrived at three principles, which appear to him to account for most of the expressions used by man and the lower animals under the influence of various emotions and sensations. The first of these is the principle of serviceable associated habits. Movements which are of service in gratifying some desire, or in relieving some sensation, become by repetition so habitual that they are performed, whether they are of any service or not, whenever the same desire or sensation is felt, even in a very weak degree. Actions, which were at first performed consciously, become, through habit and association, reflex or automatic—the sensory nerve-cells exciting the motor nerve-cells, without first communicating with those cells on which our consciousness and volition depend. Starting at the approach of danger, and blinking with the eyelids so as to protect the eyes, become perfectly spontaneous. Reflex actions, too, gained for one purpose, may be modified independently of the will or of habit, so as to serve for some other distinct purpose; or, they may be developed through natural selection. And they are thus often brought into play in connection with movements expressive of emotion. When movements associated through habit with certain mental states are partially

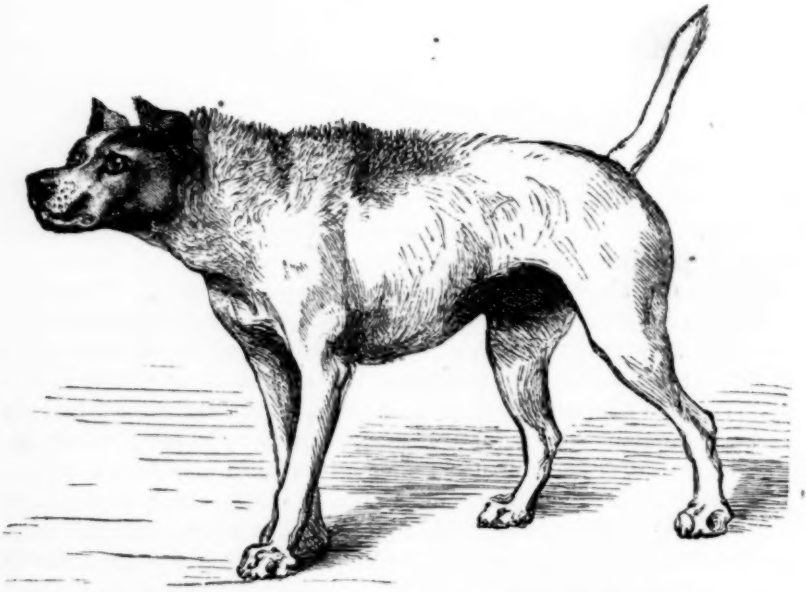
repressed by the will, the strictly involuntary muscles retain their action, and may be highly expressive; and when, on the other hand, the will is relaxed, the voluntary muscles fail before them. Debility of the brain, Sir C. Bell remarked, is most shown in the case of those muscles which are in their natural condition most under the control of the will. A further mode of expression arises when the checking of one habitual movement calls up another.

"The second principle is that of antithesis. When certain movements or gestures have been acquired as aforesaid, and have come to be habitually performed in connection with a certain state of mind, there will then be a strange and involuntary tendency under the opposite state of mind to directly opposite movements, whether in any way serviceable or not. Hence alone, Mr. Darwin thinks, can be explained, not only the sudden and extreme changes of expression in the attitudes of animals, but many gestures used by savages, or by the deaf and dumb. This antithesis in attitude, from anger and defiance to affectionate crouching, is illustrated by him in the case of the dog and the cat, by means of photography. The Cistercian monks, among whom speaking was sinful, invented a gesture language, founded upon the principle of antithesis. It is clear that in this principle the will intervenes largely.

"Mr. Darwin is, however, less confident in referring expressive signs or gestures to the action of this principle, than to his third originating cause, *the direct agency of the nervous system.* When the sensorium is strongly excited, nerve-force is generated in great excess, and is transmitted in certain directions, determined by the connection of the nerve-cells, or, where the muscular system is concerned, by the nature of the movements of face or limb, which correspond to each nervous impulse. These are, at the first, at least, independent of the will, or even of habit, though in later stages habit may have considerable play, inasmuch as nerve-force tends to pass along accustomed channels. Mr. Darwin inclines to think that what seem the most strictly involuntary actions, such as the bristling of the hair in fear or anger, may have been effected by the mysterious power of the will. He is far, however, from laying down dogmatic views upon the operation of these various agencies in causing or varying expression, nor is he prepared to draw sharp lines between the action of his three elementary principles. Many phases or signs of expression may partake, he considers, of all three, and may be referable to no single or direct physiological cause. The visible apparatus of expression may of course be taken as muscular, and he begins with laying down diagrams of the various muscles of the face in man, those in particular which are connected with the eyes and mouth. . . . . Suppose we take as an illustration the oblique or upturned eyebrows of a man suffering from grief or anxiety. Every one must be familiar, both from Nature and works of art, with the way in which the inner angle of the eye-

brow is drawn up under this emotion, the forehead being contracted or wrinkled at the same time. Mr. Darwin evolves the origin of this involuntary movement, through the same logical train of sequence by which we have seen him, in his earlier and more elaborate works, draw out the extraordinarily complex chain of laws, which runs through natural history. When infants scream loudly from hunger or pain, the circulation is affected, and the eyes tend to become gorged with blood. In consequence, the muscles surrounding the eyes are strongly contracted by an involuntary action as a protection. This action, in the course of many generations, has become firmly fixed and inherited. With advancing years and culture, the habit of screaming is partially repressed; but the muscles round the eyes still tend to contract when-

FIG. 1.



DOG APPROACHING ANOTHER DOG WITH HOSTILE INTENTIONS.—(By M. Riviere.)

ever even slight distress is felt. Of these the pyramidal muscles of the nose are less under the control of the will than the others, and their contraction can be checked only by that of the central fasciæ of the frontal muscle. These latter fasciæ draw up the inner ends of the eyebrows, and wrinkle the forehead in the peculiar manner which we immediately recognize as the expression of grief or anxiety. Laughter and tears form media of expression, which have been often subjected to analysis, but never with the same physiological minuteness and precision as in Mr. Darwin's special chapters on the phenomena of the vaso-muscular and nervous systems. The excess of nervous

energy produced by pleasure and enjoyment, passing on by an efflux through the motor nerves to various classes of the muscles, finds a vent in joyous merriment, dancing, clapping the hands, and, above all, in emissions of sound and motions of the zygomatic muscles, which draw the mouth backward and upward. From the manner in which the upper teeth are exposed in laughter and broad smiling, Mr. Darwin cannot doubt that some of the muscles running to the upper lip are likewise brought into moderate action. The upper and lower orbicular muscles of the eyes are at the same time more or less contracted, while the contractile force exerted upon the vessels or glands of the eye causes the same flow of tears in extreme laughter as in sorrow. Both laughing and weeping are seen in a minor degree in many of the lower animals. In children tears do not flow, Mr. Darwin assures us, at the first, but are induced by the effect of prolonged screaming, in gorging the vessels of the eye. This suffusion, leading at first consciously, and at last habitually, to the contraction of the muscles round the eyes, in order to protect or relieve them, the lachrymal glands become affected through reflex action. Thus, although in the

FIG. 2.

THE SAME IN A HUMBLE AND AFFECTIONATE FRAME OF MIND.—(By M. Riviere.)

first instance a merely incidental result, as purposeless as the secretion of tears from a blow outside the eye, or as a sneeze from bright light affecting the retina, we may understand how the shedding of tears serves as a natural relief to suffering."

Mr. Darwin's work is profusely illustrated by woodcuts and photographs of the human face, and of the attitudes and expressions of various animals. We give some of his figures, with his accompanying descriptions, exemplifying the principle of antithesis in the dog and cat.

He says: "When a dog approaches a strange dog or man in a savage or hostile frame of mind, he walks upright and very stiffly; his head is slightly raised, or not much lowered; the tail is held erect and quite rigid; the hairs bristle, especially along the neck and back; the pricked ears are directed forward, and the eyes have a fixed stare. (*See* Figs. 1 and 3.) These actions, as will hereafter be explained, follow from the dog's intention to attack his enemy, and are thus to a large extent intelligible. As he prepares to spring with a savage growl on his enemy, the canine teeth are uncovered, and the ears are pressed close backward on the head; but with these latter actions we are not here concerned. Let us now suppose that the dog suddenly

FIG. 3.

HALF-BRED SHEPHERD DOG IN THE SAME STATE AS IN FIG. 1.—(By Mr. A. May.)

discovers that the man whom he is approaching is not a stranger, but his master; and let it be observed how completely and instantaneously his whole bearing is reversed. Instead of walking upright, the body sinks downward or even crouches, and is thrown into flexuous movements: his tail, instead of being held stiff and upright, is lowered and wagged from side to side; his hair instantly becomes smooth; his ears are depressed and drawn backward, but not closely to the head; and his lips hang loosely. From the drawing back of the ears, the eyelids become elongated, and the eyes no longer appear round and staring. It should be added that the animal is at such times in an excited con-

dition from joy; and nerve-force will be generated in excess, which naturally leads to action of some kind. None of the above movements, so clearly expressive of affection, are of the least direct service to the animal. They are explicable, as far as I can see, solely from being in complete opposition or antithesis to the attitude and movements which, from intelligible causes, are assumed when a dog intends to fight, and which consequently are expressive of anger. I request

Fig. 4.

The same caressing his Master.—(By Mr. A. May.)

the reader to look at the four accompanying sketches, which have been given in order to recall vividly the appearance of a dog under these two states of mind. It is, however, not a little difficult to represent affection in a dog, while caressing his master and wagging his tail, as the essence of the expression lies in the continuous flexuous movements.

"We will now turn to the cat. When this animal is threatened by a dog, it arches its back in a surprising manner, erects its hair, opens its mouth and spits. But we are not here concerned with this well-known attitude, expressive of terror combined with anger; we are concerned only with that of rage or anger. This is not often seen, but may be observed when two cats are fighting together; and I have

FIG. 5. CAT, SAVAGE AND PREPARED TO FIGHT.—(Drawn from Life by Mr. Wood.)

seen it well exhibited by a savage cat while plagued by a boy. The attitude is almost exactly the same as that of a tiger disturbed and growling over its food, which every one must have beheld in menageries. The animal assumes a crouching position, with the body ex-

tended; and the whole tail, or the tip alone, is lashed or curled from side to side. The hair is not in the least erect. Thus far, the attitude and movements are nearly the same as when the animal is prepared to spring on its prey, and when, no doubt, it feels savage. But, when preparing to fight, there is this difference, that the ears are closely pressed backward; the mouth is partially opened, showing the teeth; the fore-feet are occasionally struck out with protruded claws; and the animal occasionally utters a fierce growl. (*See* Figs. 5 and 6.) All, or almost all, these actions naturally follow (as hereafter to be explained) from the cat's manner and intention of attacking its enemy.

Fig. 6.

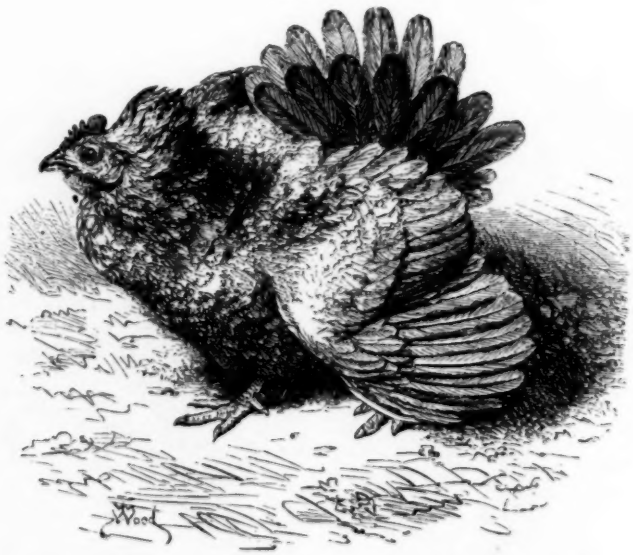
Cat, in an Affectionate Frame of Mind.—(By Mr. Wood.)

"Let us now look at a cat in a directly opposite frame of mind, while feeling affectionate and caressing her master; and mark how opposite is her attitude in every respect. She now stands upright, with her back slightly arched, which makes the hair appear rather rough, but it does not bristle; her tail, instead of being extended and lashed from side to side, is held quite stiff and perpendicularly upward; her

ears are erect and pointed; her mouth is closed; and she rubs against her master with a purr instead of a growl. Let it further be observed how widely different is the whole bearing of an affectionate cat from that of a dog, when, with his body crouching and flexuous, his tail lowered and wagging, and ears depressed, he caresses his master. This contrast in the attitudes and movements of these two carnivorous animals, under the same pleased and affectionate frame of mind, can be explained, as it appears to me, solely by their movements standing in complete antithesis to those which are naturally assumed, when these animals feel savage and are prepared either to fight or to seize their prey.

"In these cases of the dog and cat, there is every reason to believe that the gestures both of hostility and affection are innate or inherited; for they are almost identically the same in the different races of the species, and in all the individuals of the same race, both young and old."

FIG. 7.



HEN DRIVING AWAY A DOG FROM HER CHICKENS.—(Drawn from Life by Mr. Wood.)

Mr. Darwin has an interesting chapter on the erection of the dermal appendages as expressive of emotion. He observes: "Hardly any expressive movement is so general as the involuntary erection of the hairs, feathers, and other dermal appendages; for it is common throughout three of the great vertebrate classes. These appendages are erected under the excitement of anger or terror; more especially when these emotions are combined, or quickly succeed each other. The action serves to make the animal appear larger and more fright-

ful to its enemies or rivals, and is generally accompanied by various voluntary movements adapted for the same purpose, and by the utterance of savage sounds. Mr. Bartlett, who has had such wide experience with animals of all kinds, does not doubt that this is the case; but it is a different question whether the power of erection was primarily acquired for this special purpose.

"With the carnivora the erection of the hair seems to be almost universal, often accompanied by threatening movements, the uncovering of the teeth, and the utterance of savage growls. The enraged lion erects his mane. The bristling of the hair along the neck and back of the dog, and over the whole body of the cat, especially on the tail, is familiar to every one. With the cat it apparently occurs only under fear; with the dog, under anger and fear; but not, as far as I have observed, under abject fear, as when a dog is going to be flogged by a severe game-keeper. If, however, the dog shows fight, as sometimes happens, up goes his hair. I have often noticed that the hair of a dog is particularly liable to rise, if he is half angry and half afraid, as on beholding some object only indistinctly seen in the dusk.

FIG. 8.

SWAN DRIVING AWAY AN INTRUDER.—(Drawn from Life by Mr. Wood.)

"I have been assured by a veterinary surgeon that he has often seen the hair erected on horses and cattle, on which he had operated and was going again to operate.

"Birds belonging to all the chief orders ruffle their feathers when angry or frightened. Every one must have seen two cocks, even quite

young birds, preparing to fight with erected neck-hackles; nor can these feathers when erected serve as a means of defence, for cock-fighters have found by experience that it is advantageous to trim them. The male ruff (*Machetes pugnax*) likewise erects its collar of feathers when fighting. When a dog approaches a common hen with her chickens, she spreads out her wings, raises her tail, ruffles all her feathers, and, looking as ferocious as possible, dashes at the intruder. The tail is not always held in exactly the same position; it is sometimes so much erected, that the central feathers, as in the accompanying drawing, almost touch the back. Swans, when angered, likewise raise their wings and tail, and erect their feathers. They open their beaks, and make by paddling little rapid starts forward, against any one who approaches the water's edge too closely. Tropic birds[1] when disturbed on their nests are said not to fly away, but 'merely to stick out their feathers and scream.' The barn-owl, when approached, 'instantly swells out its plumage, extends its wings and tail, hisses and clacks its mandibles with force and rapidity.'[2] So do other kinds of owls. Hawks, as I am informed by Mr. Jenner Weir, likewise ruffle their feathers, and spread out their wings and tail under similar circumstances. Some kinds of parrots erect their feathers; and I have seen this action in the cassowary, when angered at the sight of an ant-eater. Young cuckoos in the nest raise their feathers, open their mouths widely, and make themselves as frightful as possible.

"Small birds, also, as I hear from Mr. Weir, such as various finches, buntings, and warblers, when angry, ruffle all their feathers, or only those round the neck; or they spread out their wings and tail-feathers. With their plumage in this state, they rush at each other with open beaks and threatening gestures. Mr. Weir concludes from his large experience that the erection of the feathers is caused much more by anger than by fear. He gives as an instance a hybrid goldfinch of a most irascible disposition, which, when approached too closely by a servant, instantly assumes the appearance of a ball of ruffled feathers. He believes that birds when frightened, as a general rule, closely adpress all their feathers, and their consequently diminished size is often astonishing. As soon as they recover from their fear or surprise, the first thing which they do is to shake out their feathers. The best instances of this adpression of the feathers and apparent shrinking of the body from fear, which Mr. Weir has noticed, have been in the quail and grass-parrakeet. The habit is intelligible in these birds from their being accustomed, when in danger, either to squat on the ground or to sit motionless on a branch, so as to escape detection. Though, with birds, anger may be the chief and commonest cause of the erection of the feathers, it is probable that young cuckoos when looked at in the

[1] *Phaeton rubricauda:* "Ibis," vol. iii., 1861, p. 180.

[2] On the *Strix flammea*, Audubon, "Ornithological Biography," 1864, vol. ii., p. 407 I have observed other cases in the Zoological Gardens.

nest, and a hen with her chickens when approached by a dog, feel at least some terror. Mr. Tegetmeier informs me that, with game-cocks, the erection of the feathers on the head has long been recognized in the cockpit as a sign of cowardice."

In his chapter on the special expressions of animals, Mr. Darwin thus speaks of the monkeys: "With monkeys the expression of slight pain, or of any painful emotion, such as grief, vexation, jealousy, etc., is not easily distinguished from that of moderate anger; and these states of mind readily and quickly pass into each other. Grief, however, with some species is certainly exhibited by weeping. A woman, who sold a monkey to the Zoological Society, believed to have come from Borneo, said that it often cried; and Mr. Bartlett, as well as the keeper, Mr. Sutton, has repeatedly seen it, when grieved, or even when much pitied, weeping so copiously that the tears rolled down its cheeks. There is, however, something strange about this case, for two specimens subsequently kept in the Gardens, and believed to be the same species, have never been seen to weep, though they were carefully observed by the keeper and myself when much distressed and loudly screaming. Rengger states that the eyes of the *Cebus azaræ* fill with tears, but not sufficiently to overflow, when it is prevented getting some much-desired object, or is much frightened. Humboldt also asserts that the eyes of the *Callithrix sciureus* 'instantly fill with tears when it is seized with fear;' but when this pretty little monkey in the Zoological Gardens was teased, so as to cry out loudly, this did not occur. I do not, however, wish to throw the least doubt on the accuracy of Humboldt's statement.

"The appearance of dejection in young orangs and chimpanzees, when out of health, is as plain and almost as pathetic as in the case of our children. This state of mind and body is shown by their listless movements, fallen countenances, dull eyes, and changed complexion.

"Baboons often show their passion and threaten their enemies in a very odd manner, namely, by opening their mouths widely, as in the act of yawning. Mr. Bartlett has often seen two baboons, when first placed in the same compartment, sitting opposite to each other and thus alternately opening their mouths; and this action seems frequently to end in a real yawn. Mr. Bartlett believes that each animal wishes to show to the other that he is provided with a formidable set of teeth, as is undoubtedly the case. As I could hardly credit the reality of this yawning gesture, Mr. Bartlett insulted an old baboon and put him into a violent passion; and he almost immediately thus acted. Some species of Macacus and of Cercopithecus behave in the same manner. Baboons likewise show their anger, as was observed by Brehm with those which he kept alive in Abyssinia, in another manner, namely, by striking the ground with one hand, 'like an angry man striking the table with his fist.' I have seen this movement with the baboons in the Zoological Gardens; but sometimes the action

seems rather to represent the searching for a stone or other object in their beds of straw.

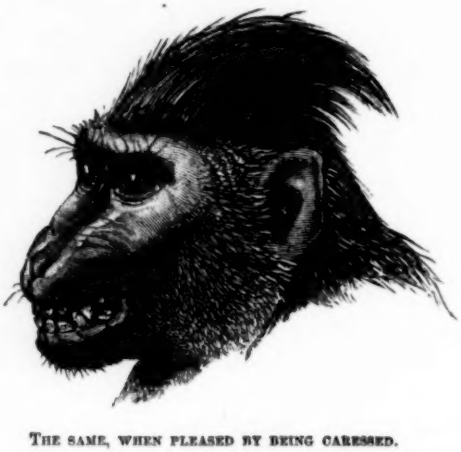
"A young orang, made jealous by her keeper attending to another monkey, slightly uncovered her teeth, and, uttering a peevish noise

FIG. 9.

Cynopithecus niger, IN A PLACID CONDITION.—(Drawn from Life by Mr. Wolf.)

like *tish-shist*, turned her back on him. Both orangs and chimpanzees, when a little more angered, protrude their lips greatly, and make a

FIG. 10.



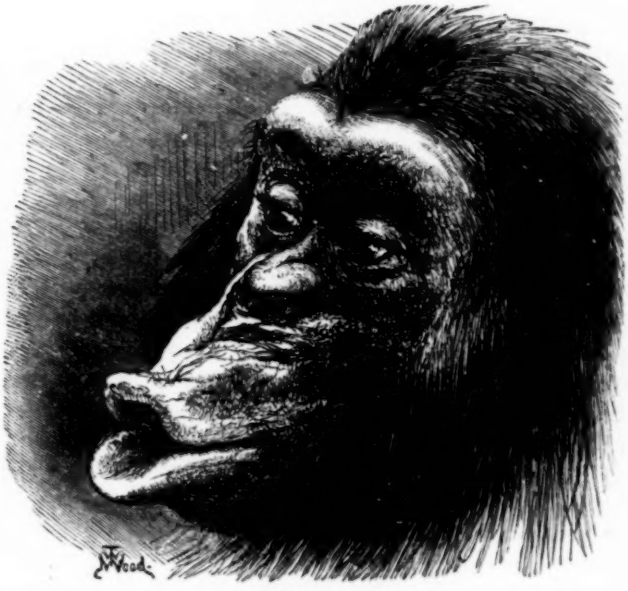
THE SAME, WHEN PLEASED BY BEING CARESSED.

harsh barking noise. A young female chimpanzee, in a violent passion, presented a curious resemblance to a child in the same state.

She screamed loudly with widely-open mouth, the lips being retracted so that the teeth were fully exposed. She threw her arms wildly about, sometimes clasping them over her head. She rolled on the ground, sometimes on her back, sometimes on her belly, and bit every thing within reach. A young gibbon (*Hylobates syndactylus*) in a passion has been described[1] as behaving in almost exactly the same manner.

"The lips of young orangs and chimpanzees are protruded, sometimes to a wonderful degree, under various circumstances. They act thus, not only when slightly angered, sulky, or disappointed, but when alarmed at any thing—in one instance, at the sight of a turtle[2]—and

FIG. 11.



CHIMPANZEE DISAPPOINTED AND SULKY.—(Drawn from Life by Mr. Wood.)

likewise when pleased. But neither the degree of protrusion nor the shape of the mouth is exactly the same, as I believe, in all cases; and the sounds which are then uttered are different. The accompanying drawing represents a chimpanzee made sulky by an orange having been offered him, and then taken away. A similar protrusion or pouting of the lips, though to a much slighter degree, may be seen in sulky children."

[1] G. Bennett, "Wanderings in New South Wales," etc., vol. ii., 1834, p. 153.

[2] W. C. Martin, "Natural History of Mammiferous Animals," 1841, p. 405.

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

VII.—*Subjective Difficulties—Emotional.*

THAT passion perverts judgment, is an observation sufficiently trite; but the more general observation of which it should form part, that emotion of every kind and degree disturbs the intellectual balance, is not trite, and, even where recognized, is not duly taken into account. Stated in full, the truth is that no propositions, save those which are absolutely indifferent to us, immediately and remotely, can be contemplated without likings and repugnances affecting the opinions we form about them. There are two modes in which our conclusions are thus falsified. Excited feelings make us wrongly estimate probability, and also make us wrongly estimate importance. Some cases will show this.

All, who are old enough, remember the murder committed by Müller on the North London Railway some years ago; for, even after reaching that stage at which accounts of crime lose their interest, and police-reports become unreadable, it is impossible to avoid gathering from gossip some knowledge of startling tragedies. Most persons, too, will remember that for some time afterward there was universally displayed a dislike to travelling by railway in company with a single other passenger—supposing him to be unknown. Though, up to the date of the murder in question, almost innumerable journeys had been made by two strangers together in the same compartment without evil being suffered by either—though, after the death of Mr. Briggs, the probabilities were immense against the occurrence of a similar fate to another person similarly placed—yet there was habitually roused a fear that would have been appropriate only had the danger been considerable. The amount of feeling excited was quite incommensurate with the risk. Though the chance was a million to one against evil, the anticipation of evil was as strong as though the chance had been a thousand to one or a hundred to one. The emotion of dread destroyed the balance of judgment, and a true estimate of likelihood became impossible; or, rather, any rational estimate of likelihood that might be formed was wholly inoperative on conduct.

Another instance was thrust on my attention during the small-pox epidemic, which a while since so unaccountably spread, after twenty years of compulsory vaccination. A lady living in London, sharing in the general trepidation, was expressing her fears to me. I asked her whether, if she lived in a town of 20,000 inhabitants, and heard of one person dying of small-pox in the course of a week, she would be much alarmed. Naturally she answered, "No;" and her fears

were somewhat calmed when I pointed out that, taking the whole population of London, and the number of deaths per week from small-pox, this was about the rate of mortality at that time caused by it. Yet in other minds, as in her mind, panic had produced an entire incapacity for forming a rational estimate of the danger. Nay, indeed, so perturbing was the emotion that an unusual amount of danger to life was imagined at a time when the danger to life was smaller than usual. For the returns showed that the mortality from all causes was rather below the average than above it. While the evidence proved that the risk of death was unusually small, this wave of feeling which spread through society produced an irresistible conviction that it was unusually great.

These examples show in a clear way, what is less clearly shown in countless other examples, that the associated ideas constituting a judgment are much affected in their relations to one another by the coexisting emotion. Two ideas will cohere feebly or strongly according as the correlative nervous states involve a feeble or a strong discharge along the lines of nervous connection; and hence a large wave of feeling, implying as it does a voluminous discharge in all directions, renders such two ideas more coherent. This is so even when the feeling is irrelevant, as is shown by the vivid recollection of trivialities observed on occasions of great excitement; and it is still more so when the feeling is relevant—that is, when the proposition formed by these ideas is itself the cause of excitement. Much of the emotion tends in such case to discharge itself through the channels connecting the elements of the proposition; and predicate follows subject with a vividness and persistence out of all proportion to that which is justified by experience.

We see this with emotions of all orders. How greatly maternal affection falsifies a mother's estimate of her child, every one observes. How those in love fancy superiorities where none are visible to unconcerned spectators, and remain blind to defects that are conspicuous to every one else, is matter of common remark. Note, too, how in the holder of a lottery-ticket hope generates a belief utterly at variance with probability as numerically estimated, and how an excited inventor has a confidence in success which calm judges see to be impossible. That "the wish is father to the thought," here so obviously true, is true more or less in nearly all cases where there is a wish. And in other cases, again, as where horror is aroused by the fancy of something supernatural, we see that, in the absence of wish to believe, there may yet arise belief if violent emotion goes along with the ideas that are joined together.

Though there is some recognition of the fact that men's judgments on social questions are distorted by their emotions, the recognition is

extremely inadequate. Political passion, class-hatred, and feelings of great intensity, are alone habitually admitted to be large factors in determining opinions. But, as above implied, we have to take account of emotions of many kinds and of all degrees, down to slight likes and dislikes. For, if we look closely into our own beliefs on public affairs, as well as into the beliefs of those around us, we find them to be caused much more by aggregates of feelings than by examinations of evidence. No one, even if he tries, succeeds in preventing the slow growth of sympathies with, or antipathies to, certain institutions, customs, ideas, etc.; and, if he watches himself, he will perceive that unavoidably each new question coming before him is considered in relation to the mass of convictions which have been gradually moulded into agreement with his sympathies and antipathies.

When the reader has admitted, as he must if he is candid with himself, that his opinion on any political act or proposal is commonly formed in advance of direct evidence, and that he rarely takes the trouble to inquire whether direct evidence justifies it, he will see how great are those difficulties in the way of sociological science, which arise from the various emotions excited by the matters it deals with. Let us note, first, the effects of some emotions of a general kind, which we are apt to overlook.

The state of mind we call impatience is one of these. If a man swears at some inanimate thing which he cannot adjust as he wishes, or if, in wintry weather, slipping down and hurting himself, he vents his anger by damning gravitation, his folly is manifest enough to spectators, and to himself also when his irritation has died away. But in the political sphere it is otherwise. A man may here, in fact if not in word, damn a law of Nature, without being himself aware, and without making others aware, of his absurdity.

The state of feeling often betrayed toward Political Economy exemplifies this. An impatience, accompanying the vague consciousness that certain cherished convictions or pet schemes are at variance with politico-economical truths, shows itself in contemptuous words applied to these truths. Knowing that his theory of government and plans for social reformation are discountenanced by it, Mr. Carlyle manifests his annoyance by calling Political Economy "the dismal science." And, among others than his adherents, there are many belonging to all parties, retrograde and progressive, who display repugnance to this body of doctrine with which their favorite theories do not agree. Yet a little thought might show them that their feeling is much of the same kind as would be scorn vented by a perpetual-motion schemer against the principles of mechanics.

To see that these generalizations which they think of as cold and hard, and acceptable only by the unsympathetic, are nothing but statements of certain modes of action arising out of human nature,

that are no less beneficent than necessary, they need only suppose a moment that human nature had opposite tendencies. Imagine that, instead of preferring to buy things at low prices, men habitually preferred to give high prices for them; and imagine that, conversely, sellers rejoiced in getting low prices instead of high ones. Is it not obvious that production and distribution and exchange, supposing them possible under such conditions, would go on in ways utterly different from their present ways? If men went for each commodity to a place where it was difficult of production, instead of to a place where it could be produced easily, and if, instead of transferring articles of consumption from one part of a kingdom to another along the shortest routes, they habitually chose roundabout routes, so that the cost in labor and time might be the greatest, is it not clear that, could industrial and commercial arrangements of any kinds exist, they would be of natures so unlike the present ones as to be inconceivable by us? And, if this is undeniable, is it not equally undeniable that the processes of production, distribution, and exchange, as they now go on, are processes determined by certain fundamental traits in human nature, and that Political Economy is nothing more than a statement of the laws of these processes, as inevitably resulting from such traits?

That the generalizations of political economists are not all true, and that some, which are true in the main, need qualification, is very likely. But, to admit this, is not in the least to admit that there are no true generalizations of this order to be made. Those who see, or fancy they see, flaws in politico-economical conclusions, and thereupon sneer at Political Economy, remind one of the theologians who lately rejoiced so much over the discovery of an error in the estimation of the sun's distance, and thought the occasion so admirable a one for ridiculing men of science. It is characteristic of theologians to find cause for extreme satisfaction in whatever shows human imperfection; and in this case they were much elated because astronomers discovered that, while their delineation of the Solar System remains exactly right in all its proportions, the absolute dimensions assigned were too great by about one-thirtieth. In one respect, however, the comparison fails: for, though the theologians taunted the astronomers, they did not venture to include astronomy within the scope of their contempt—did not do as those to whom they are here compared, who show contempt, not for political economists only, but for Political Economy itself.

Were they calm, these opponents of the political economists would see that as, out of certain physical properties of things there inevitably arise certain modes of action, which, as generalized, constitute physical science; so out of the properties of men, intellectual and emotional, there inevitably arise certain laws of social processes, including, among others, those through which mutual aid in satisfying wants is made possible. They would see that, but for these processes,

the laws of which Political Economy seeks to generalize, men would have continued in the lowest stage of barbarism to the present hour; they would see that, instead of jeering at the science and those who pursue it, their course should be to show in what respects the generalizations thus far made are untrue, and how they may be so expressed as to correspond to the truth more nearly.

I need not further exemplify the perturbing influence of impatience in sociological inquiry. Along with the irrational hope so conspicuously shown by every party having a new project for the furtherance of human welfare, there habitually goes this irrational irritation in presence of stern truths which negative sanguine anticipations. Be it some way of remedying the evils of competition, some scheme for rendering the pressure of population less severe, some method of organizing a government so as to secure complete equity, some plan for reforming men by teaching, by restriction, by punishment; any thing like calm consideration of probabilities, as estimated from experience, is excluded by this eagerness for an immediate result; and, instead of submission to the necessities of things, there comes vexation, felt if not expressed, against them, or against those who point them out, or against both.

That feelings of love and hate make rational judgments impossible in public affairs, as in private affairs, we can clearly enough see in others, though not so clearly in ourselves. Especially can we see it when these others belong to an alien society. France, during and since the late war, has furnished us almost daily with illustrations. The fact that, while the struggle was going on, any foreigner in Paris was liable to be seized as a Prussian, and that, if charged with being a Prussian, he was forthwith treated as one, sufficiently proves that hate makes rational estimation of evidence impossible. The marvellous distortions which this passion produces were abundantly exemplified during the reign of the Commune; and yet again after the Commune was subdued. The "preternatural suspicion," as Mr. Carlyle called it, which characterized conduct during the first revolution, characterized conduct during the late catastrophe. And it is displayed still. The sayings and doings of French political parties, alike in the Assembly, in the press, and in private societies, show that mutual hate causes mutual misinterpretations, fosters false conclusions, and utterly vitiates sociological generalizations.

While, however, it is manifest to us that, among our neighbors, strong sympathies and antipathies stand in the way of reasonable views and well-balanced policy, we do not perceive that among ourselves sympathies and antipathies distort judgments in degrees, not perhaps so extreme, but still in very great degrees. Instead of French opinion on French affairs, let us take English opinion on French affairs —not affairs of recent date, but affairs of the past; and, instead of a case showing the false estimation of evidence which sympathies and

antipathies produce, let us take a case showing how perverted may be the estimates of the relative gravities of evils, and the relative degrees of blameworthiness of actions.

Feudalism had decayed: its benefits had died out, and only its evils had survived. While the dominant classes no longer performed their functions, they continued their exactions and maintained their privileges. Seignorial power was exercised solely for private benefit, and at every step met the unprivileged with vexatious claims and restrictions. The peasant was called from his heavily-burdened bit of land to work gratis for a neighboring noble, who gave him no protection in return. He had to bear uncomplainingly the devouring of his crops by this man's game; to hand him a toll before he could cross the river; to buy from him the liberty to sell at market—nay, such portion of grain as he reserved for his own use he could eat only after paying for the grinding of it at his seigneur's mill, and for having it baked at his bakehouse. And then, added to the seignorial exactions, came the exactions of the Church, still more mercilessly enforced. Along with all these local abuses and exasperating obstacles to living, there had gone on at the governing centre maladministration, corruption, extravagance: treasures were spent in building vast palaces, and enormous armies were sacrificed in inexcusable wars. Profuse expenditure, demanding more than could be got from crippled industry, had caused a chronic deficit. New taxes on the poor workers brought in no money, but only clamor and discontent; and to tax the rich idlers proved to be impracticable: the proposal, that the clergy and *noblesse* should no longer be exempt from burdens such as were borne by the people, brought from these classes "a shriek of indignation and astonishment." And then, to make more conspicuous the worthlessness of the governing agencies of all orders, there was the corrupt life led by the court, from the king downward —France lying "with a harlot's foot on its neck." Passing over the various phases of the break-up which ended this intolerable state—phases throughout which the dominant classes, good for nothing and unrepentant, strove to recover their power, and, enlisting foreign rulers, brought upon France invading armies—we come presently to a time when, in a storm of anger and fear, the people revenged themselves on such of their past tormentors as remained among them. Leagued, as many of these were, with those of their order who were levying war against liberated France—leagued, as many others were supposed to be, with these enemies to the Republic at home and abroad—incorrigible as they proved themselves by their plottings and treacheries; there at length came down upon them the September massacres and the Reign of Terror, during which nearly 10,000 of those implicated, or supposed to be implicated, were killed or formally executed. The Nemesis was sufficiently fearful. Lamentable sufferings and death fell on innocent as well as guilty. Hate and despair combined to

arouse an undistinguishing cruelty, and, in some of the leading actors, a cold-blooded ferocity. Nevertheless, recognizing all this—recognizing also the truth that those who wreaked this vengeance were intrinsically no better than those on whom it was wreaked—we must admit that the bloodshed had its excuse. The panic of a people threatened with reimposition of dreadful shackles was not to be wondered at. That the expected return of a time like that, in which gaunt figures and haggard faces about the towns and the country indicated the social disorganization, should excite men to a blind fury, was not unnatural. If they became frantic at the thought that there was coming back a state under which there might again be a slaying of hundreds of thousands of men in battles fought to gratify the spite of a king's concubine, we need not be greatly astonished. And some of the horror expressed at the fate of the ten thousand victims might fitly be reserved for the abominations which caused it.

From this partially-excusable bloodshed, over which men shudder excessively, let us turn now to the immeasurably greater bloodshed, having no excuse, over which they do not shudder at all. Out of the sanguinary chaos of the Revolution, there presently rose a soldier whose immense ability, joined with his absolute unscrupulousness, made him now general, now consul, now autocrat. He was untruthful in an extreme degree, lying in his dispatches day by day, never writing a page without bad faith,[1] nay, even giving to others lessons in telling falsehoods.[2] He professed friendship while plotting to betray, and quite early in his career made the wolf-and-lamb fable his guide. He got antagonists into his power by promises of clemency, and then executed them. To strike terror, he descended to barbarities like those of the blood-thirsty conquerors of old, of whom his career reminds us: as in Egypt, when, to avenge fifty of his soldiers, he beheaded 2,000 fellahs, throwing their headless corpses into the Nile; or as at Jaffa, when 2,500 of the garrison, who finally surrendered, were at his order deliberately massacred. Even his own officers, not over-scrupulous, as we may suppose, were shocked by his brutality—sometimes refusing to execute his sanguinary decrees. Indeed, the instincts of the savage were scarcely at all qualified in him by what we call moral sentiments; as we see in his proposal to burn "two or three of the larger communes" in La Vendée; as we see in his wish to introduce bull-fights into France, and to revive the combats of the Roman arena; as we see in the cold-blooded sacrifice of his own soldiers, when he ordered a useless outpost attack merely that his mistress might witness an engagement! That such a man should have prompted the individual killing of leading antagonists, and set prices on their heads, as in the cases of Mourad-Bey and Count Frotté, and that to remove the Duc d'Enghien he should have committed a crime

[1] Translation of Lanfrey, vol. ii., p. 25.

[2] Ibid., vol. ii., p. 442.

like in its character to that of one who hires a bravo, but unlike by entailing no danger, was quite natural. It was natural, too, that, in addition to countless treacheries and breaches of faith in his dealings with foreign powers, such a man should play the traitor to his own nation, by stamping out its newly-gained free institutions, and substituting his own military despotism. Such being the nature of the man, and such being a few illustrations of his cruelty and unscrupulousness, contemplate now his greater crimes and their motives. Year after year he went on sacrificing by tens of thousands and hundreds of thousands the French people and the people of Europe at large, to gratify his lust of power and his hatred of opponents. To feed his insatiable ambition, and to crush those who resisted his efforts after universal dominion, he went on seizing the young men of France, forming army after army that were destroyed in destroying like armies raised by neighboring nations. In the Russian campaign alone, out of 552,000 French left dead or prisoners, but a small portion returned to France; while the Russian force of more than 200,000 was reduced to 30,000 or 40,000: implying a total sacrifice of considerably more than half a million lives. And when the mortality on both sides by death in battle, by wounds and by disease, throughout all the Napoleonic campaigns is summed up, it exceeds, at the lowest computation, two millions.[1] And all this slaughter, all this suffering, all this devastation, was gone through because one man had a restless desire to be despot over all men.

And now what has been thought and felt in England about the two sets of events above contrasted, and about the actors in them? For the bloodshed of the Revolution there has been utter detestation, and for those who wrought it unqualified hate. For the immeasurably greater bloodshed which these wars of the Consulate and the Empire entailed, little or no horror is expressed; while the feeling toward the

[1] M. Lanfrey sets down the loss of the French alone, from 1802 onward, at nearly two millions. This may be an over-estimate; though, judging from the immense armies raised in France, such a total seems quite possible. The above computation of the losses to European nations in general has been made for me by adding the numbers of killed and wounded in the successive battles, as furnished by such statements as are accessible. The total is 1,500,000. This number has to be greatly increased by including losses not specified—the number of killed and wounded on one side only, being given in some cases. It has to be further increased by including losses in numerous minor engagements, the particulars of which are unknown. And it has to be further increased by allowance for understatement of his losses, which was habitual with Napoleon. Though the total, raised by these various additions probably to something over two millions, includes killed and wounded, from which last class a large deduction has to be made for the number who recovered, yet it takes no account of the loss by disease. This may be set down as greater in amount than that which battles caused. (Thus, according to Kolb, the British lost in Spain three times as many by diseases as by the enemy; and in the expedition to Walcheren seventeen times as many.) So that the loss by killed and wounded and by disease, for all the European nations during the Napoleonic campaigns, is probably much understated at two millions.

modern Attila who was guilty of this bloodshed is shown by decorating rooms with portraits and busts of him. See the beliefs which these respective feelings imply:

Over ten thousand deaths we may fitly shudder and lament.	Two million deaths may be contemplated without much shuddering and lamentation.
As the ten thousand were slain because of the tyrannies, and cruelties, and treacheries, committed by them or by their class, their deaths are especially pitiable.	As the two millions, innocent of offence, were taken against their wills from classes already oppressed and impoverished, the slaughter of them need not excite our pity.
The sufferings of the ten thousand and of their relatives, who expiated their own misdeeds and the misdeeds of their class, may fitly form subjects for heart-rending stories and pathetic pictures.	There is nothing heart-rending in the sufferings of the two millions who died for no crimes of their own or their class; nor need we see pathos in the fates of the poor families throughout France and all neighboring countries from which the two million victims were taken.
That despair and the indignation of a betrayed people brought about this slaughter of ten thousand, makes the atrocity without palliation.	That one man's lust of power was gratified through the deaths of the two millions, greatly palliates the sacrifice of them.

These are the antithetical propositions tacitly implied in the opinions that have been current in England about the French Revolution and the Napoleonic wars. Only by acceptance of such propositions can these opinions be defended. Such have been the emotions of men that, until quite recently, it has been the habit to speak with detestation of the one set of events, and to speak of the other set of events in words betraying admiration. Nay, even now these feelings are but partially qualified. While the names of the leading actors in the Reign of Terror are names of execration, we speak of Napoleon as "the Great," and Englishmen worship him by visiting his tomb and taking off their hats!

How, then, with such perverting emotions, is it possible to take rational views of sociological facts? Forming, as men do, such astoundingly false conceptions of the relative amounts of evils and the relative characters of motives, how can they judge truly among institutions and actions, past or present? Clearly, minds thus swayed by disproportionate hates and admirations cannot frame those balanced

conclusions, respecting social phenomena, which alone constitute Social Science.

The sentiment which thus shudders with horror at bad deeds for which there was much excuse, while to deeds immeasurably more dreadful and without excuse it gives applause very slightly qualified with blame, is a sentiment which, among other effects, marvellously perverts men's political conceptions. This awe of power, by the help of which social subordination has been, and still is, chiefly maintained—this feeling which delights to contemplate the imposing, be it in military successes, or be it in the grand pageantries, the sounding titles, and the sumptuous modes of living that imply supreme authority—this feeling which is offended by outbreaks of insubordination, and acts or words of a disloyal kind; is a feeling that inevitably generates delusions respecting governments, their capacities, their achievements. It transfigures them and all their belongings, as does every strong emotion the objects toward which it is drawn out. Just as maternal love, idealizing offspring, sees perfections but not defects, and believes in the future good behavior of a worthless son, notwithstanding countless broken promises of amendment; so this power-worship idealizes the State, as embodied either in a despot, or in king, lords, and commons, or in a republican assembly, and continually hopes in spite of continual disappointments.

How awe of power sways men's political beliefs will be perceived, on observing how it sways their religious beliefs. We shall best see this by taking an instance supplied by people whose religious ideas are extremely crude. Here is an abstract of a description given by Captain Burton:

"A pot of oil with a lighted wick was placed every night, by the half-bred Portuguese Indians, before the painted doll, the patron saint of the boat in which we sailed from Goa. One evening, as the weather appeared likely to be squally, we observed that the usual compliment was not offered to the patron, and had the curiosity to inquire why. 'Why?' vociferated the tindal (captain), indignantly, 'if that chap can't keep the sky clear, he shall have neither oil nor wick from me, d—n him!' 'But I should have supposed that in the hour of danger you would have paid him more than usual attention?' 'The fact is, Sahib, I have found out that the fellow is not worth his salt: the last time we had an infernal squall with him on board, and if he does not keep this one off, I'll just throw him overboard, and take to Santa Caterina; hang me, if I don't—the brother-in-law!'" (brother-in-law, a common term of insult).[1]

To us it seems scarcely imaginable that men should thus behave to their gods and demi-gods—should pray to them, should insult and sometimes castigate them for not answering their prayers, and then should presently pray to them again. Let us pause a moment before we laugh. Though in the sphere of religion our conduct does not pre-

[1] Burton's "Goa," etc., p. 167.

sent such a contradiction, yet a contradiction essentially similar is betrayed by our conduct in the political sphere. Perpetual disappointment does not here cure us of perpetual expectation. Conceiving the state-agency as though it were something more than a cluster of men (a few clever, many ordinary, and some decidedly stupid), we ascribe to it marvellous powers of doing multitudinous things which men otherwise clustered are unable to do. We petition it to procure for us, in some way which we do not doubt it can find, benefits of all orders; and pray it with unfaltering faith to secure us from every fresh evil. Time after time our hopes are balked. The good is not obtained, or something bad comes along with it; the evil is not cured, or some other evil as great or greater is produced. Our journals, daily and weekly, general and local, perpetually find failures to dilate upon; now blaming, and now ridiculing, first this department and then that. And yet, though the rectification of blunders, administrative and legislative, is a main part of public business—though the time of the Legislature is chiefly occupied in amending and again amending, until, after the many mischiefs implied by these needs for amendments, there often comes at last repeal; yet from day to day increasing numbers of wishes are expressed for legal repressions and state-management. This emotion which is excited by the forms of governmental power, and makes governmental power possible, is the root of a faith that springs up afresh however often cut down. To see how little the perennial confidence it generates is diminished by perennial disappointment, it needs but to remind ourselves of a few state-performances in the chief state departments.

On the second page of the first chapter, by way of illustrating Admiralty mismanagement, brief reference was made to three avoidable catastrophes which had happened to vessels-of-war within the twelvemonth. Their frequency is further shown by the fact that, before the next chapter was published, two others had occurred: the Lord Clyde ran aground in the Mediterranean, and the Royal Alfred was seven hours on the Bahama reef. And then, more recently, we have had the sinking of a vessel at Woolwich by letting a 35-ton gun fall through her bottom. That the authorities of the navy commit errors which the merchant service avoids, has been repeatedly shown of late, as in times past. It was shown by the disclosure respecting the corrosion of the Glatton's plates, which proved that the Admiralty had not adopted the efficient protective methods long used by private shipowners. It was shown when the loss of the Ariadne's sailors brought out the facts that a 26-gun frigate had not as many boats for saving life as are prescribed for a passenger-ship of less than 400 tons; and that for lowering her boats there was on board neither Kynaston's apparatus nor the much better apparatus of Clifford, which experience in the merchant service has thoroughly tested. It was shown by the non-adoption of Silver's governor for marine steam-engines; long used

in private steamships to save machinery from breakage, but not used in the navy until much machinery had been broken. On going back a little, this relative inefficiency of administration is still more strikingly shown: instance the fact that, during the Chinese Expedition of 1841, a mortality, at the rate of three or four per day in a crew of 300, arose from drinking muddy water from the paddy-fields, though, either by boiling it or by filtering it through charcoal, much of this mortality might have been prevented; instance the fact that, within the memory of living officers (I have it from the mouth of one who had the experience), vessels-of-war, leaving Deptford, filled their casks with Thames-water taken at ebb-tide, which water during its subsequent period of putrefaction had to be filtered through handkerchiefs before drinking and then swallowed while holding the nose; or instance the accumulation of abominable abuses and malversations and tyrannies which produced the mutiny at Spithead. But, perhaps, of all such illustrations, the most striking is that which the treatment of scurvy shows us. It was in 1593 that sour juices were first recommended by Albertus; and in the same year Sir R. Hawkins cured his crew of scurvy by lemon-juice. In 1600 Commodore Lancaster, who took out the first squadron of the East India Company's ships, kept the crew of his own ship in perfect health by lemon-juice, while the crews of the three accompanying ships were so disabled that he had to send his men on board to set their sails. In 1636 this remedy was again recommended in medical works on scurvy. Admiral Wagner, commanding our fleet in the Baltic in 1726, again proved it to be a specific. In 1757, Dr. Lind, the physician to the naval hospital at Haslar, collected and published, in an elaborate work, these and many other proofs of its efficacy. Nevertheless, scurvy continued to carry off thousands of our sailors. In 1780, 2,400 in the Channel Fleet were affected by it; and in 1795 the safety of the Channel Fleet was endangered by it. At length, in that year, the Admiralty ordered a regular supply of lemon-juice to the navy. Thus two centuries after the remedy was known, and forty years after a chief medical officer of the Government had given conclusive evidence of its worth, the Admiralty, forced thereto by an exacerbation of the evil, first moved in the matter. And what had been the effect of this almost incredible perversity of officialism? The mortality from scurvy during this long period had exceeded the mortality by battles, wrecks, and all casualties of sea-life put together![1]

How, through military administration, there has all along run, and still runs, a kindred stupidity and obstructiveness, pages of examples might be accumulated to show. The debates pending the abolition of the purchase-system furnish many; the accounts of life at Aldershot and of autumn manœuvres furnish many; and many might be added in the shape of protests like those made against martinet

[1] *See* Tweedie's "System of Practical Medicine," vol. v., pp. 62–69.

riding-regulations, which entail ruptures on the soldiers, and against "our ridiculous drill-book," as independent officers are now agreeing to call it. Even limiting ourselves to sanitary administration in the army, the files of our journals and the reports of our commissions would yield multitudinous instances of scarcely credible bungling—as in bad barrack arrangements, of which we heard so much a few years ago; as in an absurd style of dress, such as that which led to the wholesale cutting-down of the Twelfth Cameronians when they arrived in China in 1841; as in the carelessness which lately caused the immense mortality by cholera among the Eighteenth Hussars at Secunderabad. Or, not further to multiply instances, take the long-continued ignoring of ipecacuanha as a specific for dysentery, which causes so much mortality in our Indian service:

"It is a singular fact that the introducers of the ipecacuanha into European practice, the Brazilian traveller Maregrav, and the physician Piso (in 1648), explicitly stated that the powder is a specific cure for dysentery, in doses of a drachm and upward; but that this information appears never to have been acted upon till 1813, when Surgeon G. Playfair, of the East Indian Company's service, wrote testifying to its use in these doses. Again, in 1831, a number of reports of medical officers were published by the Madras Medical Board, showing its great effects in hourly doses of five grains, till frequently 100 grains were given in a short period; testimony which, notwithstanding its weight, was doomed to be similarly overlooked, till quite recently, when it has been again brought directly under the notice of the Indian Government, which is making very vigorous efforts to introduce the culture of the plant into suitable districts of India."[1]

So that, notwithstanding the gravity of the evil, and the pressing need for this remedy from time to time thrust on the attention of the Indian authorities, nearly sixty years passed before the requisite steps were taken.[2]

That the State, which fails to secure the health of men, even in its own employ, should fail to secure the health of beasts, might perhaps be taken as self-evident; though possibly some, comparing the money laid out on stables with the money laid out on cottages, might doubt the corollary. Be this as it may, however, the recent history of cattle-diseases and of legislation to prevent cattle-diseases yields the same

[1] "Report on the Progress and Condition of the Royal Gardens at Kew, 1870," p. 5.

[2] My attention was drawn to this case by one who has had experience in various government services; and he ascribed this obstructiveness in the medical service to the putting of young surgeons under old. The remark is significant, and has far-reaching implications. Putting young officials under old is a rule of all services—civil, military, naval, or other; and, in all services, necessarily has the effect of placing the advanced ideas and wider knowledge of a new generation under control by the ignorance and bigotry of a generation to which change has become repugnant. This, which is a seemingly ineradicable vice of public organizations, is a vice to which private organizations are far less liable; since, in the life-and-death struggle of competition, merit, even if young, takes the place of demerit, even if old.

lessons as are yielded above. Since 1848 there have been seven Acts of Parliament bearing the general titles of Contagious Diseases (Animals) Acts. Measures to "stamp out," as the phrase goes, this or that disease, have been called for as imperative. Measures have been passed, and then, expectation not having been fulfilled, amended measures have been passed, and then reamended measures; so that of late no session has gone by without a bill to cure evils which previous bills tried to cure, but did not. Notwithstanding the keen interest felt by the ruling classes in the success of these measures, they have succeeded so ill, that the "foot-and-mouth disease" has not been "stamped out," has not even been kept in check, but during the past year has spread alarmingly in various parts of the kingdom. Continually the *Times* has had blaming letters and reports of local meetings called to condemn the existing laws, and to insist on better. From all quarters there have come accounts of ineffective regulations and incapable officials—of policemen who do the work of veterinary surgeons—of machinery described by Mr. Fleming, veterinary surgeon of the Royal Engineers, as "clumsy, disjointed, and inefficient."[1]

Is it alleged that the goodness of State-agency cannot be judged by measures so recent, the administration of which is at present imperfect. If so, let us look at that form of State-agency which is of most ancient date, and has had the longest time for perfecting its adjustments—let us take the law in general, and its administration in general. Needs there do more than name these to remind the reader of the amazing inefficiency, confusion, doubtfulness, delay, which, proverbial from early times, continue still? Of penal statutes alone, which are assumed to be known by every citizen, 14,408 had been enacted from the time of Edward III. down to 1844. As was said by

[1] Let me here add what seems to be a not impossible cause, or at any rate part-cause, of the failure. The clew is given by a letter in the *Times*, signed "Land-owner," dating Tollesbury, Essex, August 2, 1872. He bought "ten fine young steers, perfectly free from any symptom of disease," and "passed sound by the inspector of foreign stock." They were attacked by foot-and-mouth disease after five days passed in fresh paddocks with the best food. On inquiry he found that foreign stock, however healthy, "'mostly all go down with it' after the passage." And then, in proposing a remedy, he gives us a fact of which he does not seem to recognize the meaning. He suggests, "that, instead of the present quarantine at Harwich, which consists in driving the stock from the steamer into pens for a limited number of hours," etc., etc. If this description of the quarantine is correct, the spread of the disease is accounted for. Every new drove of cattle is kept for hours in an infected pen. Unless the successive droves have been all healthy (which the very institution of the quarantine implies that they have not been), some of them have left in the pen diseased matter from their mouths and feet. Even if disinfectants are used after each occupation, the risk is great—the disinfection is almost certain to be inadequate. Nay, even if the pen is adequately disinfected every time, yet if there is not also a complete disinfection of the landing appliances, the landing-stage, and the track to the pen, the disease will be communicated. No wonder healthy cattle "'mostly go down with it' after the passage." The quarantine regulations, if they are such as here implied, might with perfect truth be called "regulations for the better diffusion of cattle-diseases."

Lord Cranworth in the House of Peers, 16th February, 1853, the judges were supposed to be acquainted with all these laws, but, in fact, no human mind could master them, and ignorance had ceased to be a disgrace.[1] To this has to be added the accumulation of civil laws, similarly multitudinous, involved, unclassified, and to this, again, the enormous mass of "case law," filling over 1,200 volumes, and rapidly increasing, before there can be formed an idea of the chaos. And then consider how there has come this chaos, out of which not even the highest legal functionaries, much less the lower functionaries, much less the ordinary citizens, can educe definite conclusions. Session after session the confusion has been worse confounded by the passing of separate Acts, and successive amendments of Acts, which are left unconnected with the multitudinous kindred Acts and amendments that lie scattered through the accumulated records of centuries. Suppose a trader should make, day by day, separate memoranda of his transactions with A, B, C, and the rest of his debtors and creditors. Suppose he should stick these on a file one after the other as they were made, never even putting them in order, much less entering them in his ledger. Suppose he should thus go on throughout his life, and that, to learn the state of his account with A, B, or C, his clerks had to search through this enormous confused file of memoranda, being helped only by their memories and by certain private note-books which preceding clerks had made for their own guidance, and left behind them. What would be the state of the business? What chance would A, B, and C, have of being rightly dealt with? Yet this, which, as a method of conducting private business, is almost too ludicrous for fiction, is in public business nothing more than grave fact. And the result of the method is exactly the one to be anticipated. At the present time we have two ex-Chancellors giving conflicting judgments in assurance-arbitrations. The conflict may be taken as typical of the system from top to bottom. Every day's law-reports remind us that each decision given is so uncertain that the probability of appeal depends chiefly on the courage or pecuniary ability of the beaten litigant—not on the nature of the verdict; and, if the appeal is made, a reversal of the verdict is looked for as by no means unlikely. And then, on contemplating the ultimate result, we find it to be—the multiplication of aggressions. Were the law clear, were the verdicts certain to be in conformity with it, and did asking for its protection entail no chance of great loss or of ruin, very many of the causes that come before our courts would never be heard of, for the reason that the wrongs they disclose would not be committed; and there would not be committed those yet more numerous wrongs to which the bad are prompted by the belief that the persons wronged will not dare to seek redress. Here, where State-agency has had centuries upon centuries in which to develop its appliances and show its efficiency, it is so

[1] Fischel's "English Constitution," translated by Shee. p. 487.

inefficient that citizens dread employing it, lest, instead of getting succor in their distress, they should bring on themselves new sufferings. And then—startling comment on the system, if we could but see it—there spring up private voluntary combinations for doing the business which the State should do, but fails to do. Here in London there is now proposed a Tribunal of Commerce, for administering justice among traders, on the pattern of that which in Paris settles many thousands of cases a year.

Even after finding the State perform so ill this vital function, one might have expected that it would perform well such a simple function as the keeping of documents. Yet, in the custody of the national records, there has been a carelessness such as "no merchant of ordinary prudence" would show in respect to his account-books. One portion of these records was for a long time kept in the White Tower, close to some tons of gunpowder, and another portion was kept close to a steam-engine in daily use. Some records were deposited in a temporary shed at the end of Westminster Hall, and thence, in 1830, they were removed to other sheds in the King's Mews, Charing Cross, where, in 1836, their state is thus described by the Report of a Select Committee:

"In these sheds 4,136 cubic feet of national records were deposited in the most neglected condition. Besides the accumulated dust of centuries, all, when these operations commenced" (the investigation into the state of the Records), "were found to be very damp. Some were in a state of inseparable adhesion to the stone walls. There were numerous fragments which had only just escaped entire consumption by vermin, and many were in the last stage of putrefaction. Decay and damp had rendered a large quantity so fragile as hardly to admit of being touched; others, particularly those in the form of rolls, were so coagulated together that they could not be uncoiled. Six or seven perfect skeletons of rats were found embedded, and bones of these vermin were generally distributed throughout the mass."

Thus, if we array in order the facts daily brought to light, but which, unhappily, drop out of men's memories as fast as others are added, we find a like history throughout. Now the complaint is of the crumbling walls of the Houses of Parliament, which, built of stone chosen by a commission, nevertheless begin to decay in parts first built before other parts are completed. Now the disclosure is about a new fort at Seaford, based on the shingle so close to the sea that a storm washes a great part of it away. And now there comes the account of a million and a half spent in building the Alderney harbor, which, being found worse than useless, threatens to entail further cost for its destruction. Scarcely a journal can be taken up that has not some blunder referred to in a debate, or brought to light by a Report, or pointed out in a letter, or commented on in a leader. Do I need an illustration? I take up the *Times* of this morning (November 13th), and read that the new bankruptcy law, substituted for the bankruptcy

laws which failed so miserably, is administered in rooms so crowded and noisy that due care and thought on the part of officials are scarcely possible; and, further, that, as one part of the court sits in the City and another part in Lincoln's Inn, solicitors have often to be in both places at the same time. Do I need more illustrations? They come in abundance between the day on which the foregoing sentence was written and the day (November 20th) on which I revise it. Within this short time mismanagement has been shown in a treatment of the police that has created a mutiny among them; in a treatment of government copying-clerks that causes them publicly to complain of broken promises; in a treatment of postmen that calls from them disrespectful behavior toward their superiors: all at the same time that there is going on the controversy about Park-rules, which have been so issued as to evade constitutional principles, and so administered as to bring the law into contempt. Yet, as fast as there come proofs of mal-administration, there come demands that administration shall be extended. Just as, in societies made restive by despotism, we see that, for the evils and dangers brought about, the remedy is more despotism; just as we see that, along with the failing power of a decaying Papacy, there goes, as the only fit cure, a reassertion of Papal infallibility with emphatic *obligato* from a Council; so, to set right the misdoings of State-agency, the proposal is always more State-agency. When, after long continuance of coal-mine inspection, coal-mine explosions keep recurring, the cry is for more coal-mine inspection. When railway accidents multiply, notwithstanding the oversight of officials appointed by law to see that railways are safe, the unhesitating demand is for more such officials. Though, as Lord Salisbury lately remarked of governing bodies deputed by the State, "they begin by being enthusiastic and extravagant, and they are very apt to end in being wooden" —though, through the press and by private conversation, men are perpetually reminded that, when it has ceased to wield the new broom, each deputy governing power tends to become either a king-stork that does mischief, or a king-log that does nothing—yet more deputy governing powers are asked for with unwavering faith. While the unwisdom of officialism is daily illustrated, the argument for each proposed new department sets out with the postulate that officials will act wisely. After endless comments on the confusion and apathy and delay of Government offices, other Government offices are advocated. After ceaseless ridicule of red-tape, the petition is for more red-tape. Daily we castigate the political idol with a hundred pens, and daily pray to it with a thousand tongues.

The emotion which thus destroys the balance of judgment lies deep in the natures of men as they have been and still are. This root, out of which there grow hopes that are no sooner blighted than kindred hopes grow up in their places, is a root reaching down to the

earliest stages of civilization. The conquering chief, feared, marvelled at, for his strength or sagacity, distinguished from others by a quality thought of as supernatural (when the antithesis of this with natural becomes thinkable), ever excites a disproportionate faith and expectation. Having done or seen things beyond the power or insight of inferiors, there is no knowing what other such things he may not do or see. After death, his deeds become magnified by tradition; and his successor, inheriting his authority, executing his commands, and keeping up secret communication with him, acquires either thus, or by his own superiority, or by both, a like credit for powers that transcend the ordinary human powers. So there accumulates an awe of the ruler, with its correlative faith. As we trace the genealogy of the governing power, thus beginning as god, and descendant of the gods, and having titles and a worship in common with the gods, we see there clings to it, through all its successive metamorphoses, more or less of this same ascribed character, exciting this same sentiment. "Divinely descended" becomes presently "divinely appointed," "the Lord's anointed," "ruler by divine right," "king by the grace of God," etc. And then as fast as declining monarchical power brings with it decreasing belief in the supernaturalness of the monarch (which, however, long lingers in faint forms, as instance the supposed cure of king's evil), the growing powers of the bodies that assume his functions bring to them a share of the still-surviving sentiment. The "divinity that doth hedge a king" becomes, in considerable measure, the divinity that doth hedge a Parliament. The superstitious reverence once felt toward the one is transferred, in a modified form, to the other, taking with it a tacit belief in an ability to achieve any end that may be wished, and a tacit belief in an authority to which no limits may be set.

This sentiment, inherited and cultivated in men from childhood upward, sways their convictions in spite of them. It generates an irrational confidence in all the paraphernalia and appliances and forms of State-action. In the very aspect of a law-deed, written in an archaic hand on dingy parchment, there is something which raises a conception of validity not raised by ordinary writing on paper. Around a Government-stamp there is a certain glamour which makes us feel as though the piece of paper bearing it was more than a mere mass of dry pulp with some indented marks. To any legal form of words there seems to attach an authority far greater than that which would be felt were the language free from legal involutions and legal technicalities. And so is it with all the symbols of authority, from royal pageants downward. That the judge's wig gives to his decisions a weight and sacredness they would not have were he bareheaded, is a fact familiar to every one. And, when we descend to the lowest agents of the executive organization, we find the same thing. A man in blue coat and white-metal buttons, which carry with them the thought

of State-authority, is habitually regarded by citizens as having a trustworthiness beyond that of a man who wears no such uniform; and this confidence survives all disproofs. Obviously, then, if men's judgments are thus ridiculously swayed, in spite of better knowledge, by the mere symbols of State-power, still more must they be so swayed by State-power itself, as exercised in ways that leave greater scope for the imagination. If awe and faith are irresistibly called out toward things which perception and reason tell us positively should not call them out, still more will awe and faith be called out toward those State-actions and influences on which perception and reason can less easily be brought to bear. If the beliefs prompted by this feeling of reverence survive even where they are flatly contradicted by common-sense, still more will they survive where common-sense cannot so flatly contradict them.

How deeply rooted is this sentiment excited in men by embodied power will be seen, on noting how it sways in common all orders of politicians, from the old-world Tory to the Red Republican. Contrasted as the extreme parties are in the types of Government they approve, and the theories they hold respecting the source of Government authority, they are alike in their unquestioning belief in governmental authority, and in showing almost unlimited faith in the ability of a Government to achieve any desired end. Though the form of the agency toward which the sentiment of loyalty is directed is much changed, yet there is little change in sentiment itself, or in the general conceptions it creates. The notion of the divine right of a person has given place to the notion of the divine right of a representative assembly. While it is held to be a self-evident falsity that the single will of a despot can justly override the wills of a people, it is held to be a self-evident truth that the wills of one-half of a people, *plus* some small fraction, may with perfect justice override the wills of the other half, *minus* this small fraction—may override them in respect of any matter whatever. Unlimited authority of a majority has been substituted for unlimited authority of an individual. So unquestioning is the belief in this unlimited authority of a majority, that even the tacit suggestion of a doubt produces astonishment. True, if, of one who holds that power deputed by the people is subject to no restrictions, you ask whether, if the majority decided that no person should be allowed to live beyond sixty, the decision might be legitimately executed, he would possibly hesitate. Or, if you asked him whether the majority, being Catholic, might rightly require of the Protestant minority that they should either embrace Catholicism or leave the country, he would, influenced by the ideas of religious liberty in which he has been brought up, probably say no. But, though his answers to sundry such questions disclose the fact that State-authority, when an embodiment of the national will, is not believed by him to be absolutely supreme, his latent conviction, that there are limits to it, lies so

remote in the obscure background of his consciousness as to be practically non-existent. In all he says about what a legislature should do, or forbid, or require, he tacitly assumes that any regulation may be enacted, and when enacted must be obeyed. And then, along with this authority not to be gainsaid, he believes in a capacity not to be doubted. Whatever the governing body decides to do can be done, is the postulate which lies hidden in the schemes of the most revolutionary reformers. Analyze the programmes of the Communalists, observe what is hoped for by the adherents of the Social and Democratic Republic, or study the ideas of legislative action which our own Trades-Unionists entertain, and you find the implied belief to be that a Government, organized after an approved pattern, will be able to remedy all the evils complained of, and to secure each proposed benefit.

Thus, the emotion excited by embodied power is one which sways, and indeed mainly determines, the beliefs, not only of those classed as the most subordinate, but even those classed as the most insubordinate. It has a deeper origin than any political creed, and more or less distorts the conceptions of all parties respecting governmental action.

This sentiment of loyalty, making it almost impossible to study the natures and actions of governing agencies with perfect calmness, greatly hinders sociological science, and must long continue to hinder it. For the sentiment is all-essential. Throughout the past, societies have been mainly held together by it. It is still an indispensable aid to social cohesion and the maintenance of order. And it will be long before social discipline has so far modified human character that reverence for law, as rooted in the moral order of things, will serve in place of reverence for the power which enforces law.

Accounts of existing uncivilized races, as well as histories of the civilized races, show us *a posteriori* what we might infer with certainty *a priori*, that, in proportion as the members of a society are aggressive in their natures, they can be held together only by a proportionately strong feeling of unreasoning reverence for a leader or a ruler. Some of the lowest types of men, who show but little of this feeling, show scarcely any social cohesion, and make no progress—instance the Australians. Where appreciable social development has taken place, we find subordination to chiefs; and, as the society enlarges, to a king. If we need an illustration that, where there is great savageness, social union can be maintained only by great loyalty, we have it among those ferocious cannibals the Fijians. Here, where the barbarism is so extreme that a late king registered by a row of many hundred stones the number of human victims he had devoured, the loyalty is so extreme that a man stands unbound to be knocked on the head if the king wills it: himself saying that the king's will must be done. And if, with this case in mind, we glance back over the past, and note the fealty that went along with brutality in feudal

ages; or if, at the present time, we observe how the least advanced European nations show a superstitious awe of the ruler, which, in the more advanced, has become conventional respect; we shall perceive that decrease of the feeling goes on, and can normally go on, only as fast as the fitness of men for social coöperation increases. Manifestly, throughout all past time, assemblages of men in whom the aggressive selfishness of the predatory nature existed without this feeling, which induces obedience to a controlling power, dissolved and disappeared, leaving the world to be peopled by those who had the required emotional balance. And it is manifest that, even in civilized society, if the sentiment of subordination becomes enfeebled without self-control gaining in strength proportionately, there arises a danger of social dissolution—a truth of which France supplies an illustration.

Hence, as above said, the conceptions of sociological phenomena, or, at least, of those all-important ones relating to governmental structures and actions, must now, and for a long time to come, be rendered more or less untrue by this perturbing emotion. Here, in the concrete, may be recognized the truth before stated in the abstract, that the individual citizen, embedded, as it were, in the social organism as one of its units, mainly moulded by its influences, and aiding reciprocally to remould it, furthering its life while enabled by it to live, cannot so emancipate himself as to see things around him in their real relations. Unless the mass of citizens have sentiments and beliefs in something like harmony with the social organization in which they are incorporated, this organization cannot continue. These sentiments proper to each type of society will inevitably sway the sociological conclusions of its units. And, among other sentiments, this awe of embodied power will take a large share in doing this.

How large a share it takes, we shall see on contemplating the astonishingly perverted estimates of rulers it has produced, and the resulting perversions of history. Recall the titles of adoration given to emperors and kings; the ascription to them of capacities, beauties, powers, virtues, transcending those of mankind in general; the fulsome flatteries used when commending them to God in prayers professing to utter the truth. Now, side by side with these, put records of their deeds throughout all past times in all nations; notice how thickly these records are sprinkled with crimes of all orders; and then dwell a while on the contrast. Is it not manifest that the conceptions of State-actions that went along with these profoundly untrue conceptions of rulers must also have been profoundly untrue? Take, as a single example, King James, who, as described by Mr. Bisset in agreement with other historians, was "in every relation of life in which he is viewed . . . . equally an object of aversion or contempt;" but to whom, nevertheless, the English translation of the Bible is dedicated in sentences beginning, "Great and manifold were the blessings, most

dread sovereign, which Almighty God, the Father of all mercies, bestowed upon us the people of England, when first He sent Your Majesty's Royal Person to rule and reign over us," etc., etc. Think of such a dedication of such a book to such a man; and then ask if, along with a sentiment thus expressing itself, there could go any thing like balanced judgments of political transactions.

Does there need an illustration of the extent to which balanced judgments of political transactions are made impossible by this sentiment during times when it is strong? We have one in the warped conceptions formed respecting Charles I. and Cromwell; and respecting the changes with which their names are identified. Now that many generations have gone by, and it begins to be seen that the one was not worthy to be prayed for as a martyr, while the other deserved treatment quite unlike that of exhuming his body and insulting it, it begins to be seen, also, how utterly wrong have been the interpretations of the events they took part in, and how entirely men's sentiments of loyalty have incapacitated them for understanding those events under their sociological aspects.

Naming this as an instance of a more special perverting effect of this sentiment, we have here chiefly to note its more general perverting effect. From the beginning it has tended ever to keep in the foreground of consciousness the governing agent as causing social phenomena; and so has kept in the background of consciousness all other causes of social phenomena—or, rather, the one has so completely occupied consciousness as to exclude the other. If we remember that history has been full of the doings of kings, but that only in quite recent times have the phenomena of industrial organization, conspicuous as they are, attracted any attention—if we remember that, while all eyes and all thoughts have been turned to the actions of rulers, no eyes and no thoughts have, until modern days, been turned to those vital processes of spontaneous coöperation by which natural life, and growth, and progress, have been carried on—we shall not fail to see how profound have been the resulting errors in men's conclusions about social affairs. And, seeing this, we shall infer that the emotion excited in men by embodied political power must now, and for a long time to come, be a great obstacle to the formation of rational sociological conceptions—tending, as it must ever do, to exaggerate the importance of the political factor in comparison with other factors.

Under the title of "Subjective Difficulties—Emotional," I have here entered upon an extensive field, the greater part of which remains to be explored. The effects of impatience, the effects of that all-glorifying admiration felt for military success, the effects of that sentiment which makes men submit to authority by keeping up a superstitious awe of the agent exercising it, are but a few among the effects which the emotions produce on sociological beliefs. Various other effects

have now to be described and illustrated. We will deal with them in chapters on "the Educational Bias," "the Bias of Patriotism," "the Class-Bias," "the Political Bias," and "the Theological Bias."

THE WARMING OF HOUSES.

By JOHN P. SEDDON, Esq.

THE usual appliances for warming houses, setting aside comprehensive systems, resolve themselves into open grates, close stoves, and, under special conditions, gas apparatus, and pipes for hot air or water for warming halls and passages.

For the whole of these certain general rules may be laid down:

1. More cannot be got out of any one of them than is put into it. This is an axiom which, truism as it appears, is necessary should be impressed upon the public mind, which is apt to assume that engineering skill can multiply the heating power of fuel indefinitely. Thus, materials like fire-clay, which are absorbent of heat and useful to prevent its escape, and retain it till needed, must abstract it first from the fuel before it can dispense it.

2. There are but 100 degrees of percentage. This simple fact should be kept in mind in considering methods of saving fuel, the inventors of which would otherwise persuade one that reference to coal-merchants is a work almost of supererogation.

3. Some proportion of the heat generated must be expended in maintaining a draught in the flue, which is to carry off the products of combustion. This is by no means unprofitably lost, since it promotes ventilation as well.

4. To minimize this proportion of escaping heat to as nearly as possible what is just necessary, and to take toll from it during its passage, as by warming the air which is to replace that abstracted by the flue, are the principal directions which efforts to economize fuel should take.

5. The products of combustion, being noxious, must be wholly removed, unless they can be chemically transformed. It is as barbarous to allow the fumes from gas to invade rooms, as it is to let the door be the sole outlet for peat-smoke in an Irish cabin, or as it was to provide only louvers in the roofs of the halls of our forefathers for the smoke of their wood-fires. The evil may be disguised, but the poison is the more insidious from being comparatively unfelt. The lungs of the living animals, as the leather of dead ones on the book-shelves, become corroded alike by its pernicious influence.

6. Warming and ventilation are so intimately connected that, although the latter is not my special subject upon this occasion, it is

necessary that it should be kept in mind throughout while treating of the former. In fact, infusing heated air is a more economical and pleasanter mode of warming houses than direct radiation, and it is only by their capability of combining the two methods that open fires can maintain ascendency over stoves, and it is only by uniting proper ventilation with stoves that they ought to be tolerated.

Lastly, all appliances should be simple and as self-acting as possible. This is essential for those intended for the use of the poor, whose treatment of them is of the roughest, and who neither need nor understand any thing complicated. If there be a damper to be drawn, or a handle to be turned by them, neither will be drawn nor turned except occasionally the wrong way, and if there be any cover or part that is loose, it is safe to be lost. At the risk, therefore, of some waste, their scanty fuel must be consumed in the most primitive manner possible. With somewhat less force the same caution may be given to those who design apparatus for the upper classes. Every thing even for them should be as self-acting as possible, for, though individuals may for a time take a fancy to an ingenious arrangement that requires personal adjustment, they tire of it in time; servants in their succession are not to be drilled into its use, and the thing is soon left to itself, and failure is the inevitable result.

To proceed to the several appliances themselves:

In the race to attain *economy*, it must be acknowledged, at the outset, that close stoves completely distance open grates, and that they in their turn are as far ahead of all gas-apparatus as at present invented; and yet all have some advantages as well as disadvantages peculiar to themselves, to which it is worth giving some consideration.

In stoves, the heat from fuel can be almost wholly extracted and utilized, and even the little that escapes with the gaseous products of combustion is heavily taxed when its ultimate exit is by the few insignificant pipes, or diminutive chimney-stalks, which alone are suffered to peep above the roofs of houses on the Continent. English ideas of comfort will not, however, permit of the general introduction of the stove system into this country, and it is hardly to be desired that it should, unless great improvement be grafted upon that in vogue abroad, in which stuffiness is ever an accompaniment of warmth.

Our British privilege, however, of being able to poke the fire, although purchased dearly by its concomitant dust and the labor it entails upon servants, is not likely soon to be relinquished, and the luxury of an open fire is a fact which no theory can demolish.

Still, the grates in common use savor of barbarism, and much can and should be done to gain further refinement, economy, and immunity from nuisance. There is no need, for instance, that our roofs should be disfigured by the ugly and even comical flue terminals which Dickens satirized in one of his latest Christmas publications. We ought not to be subject to vexatious down-draughts in windy weather, nor to

chimneys that smoke unless a door or window be open. Our drawing-rooms should not be invaded by sooty chimney-sweepers, and all ought not to have to scramble for a place near the fire in a room to be warm, nor when there to have to rotate like a smoke-jack to prevent being frozen on one side while we are scorched on the other.

Such evils are to be obviated by simple means, and yet ninety-nine out of every hundred Englishmen submit to them supinely if not patiently. Whole streets, occupied by men of means, have their sky-line fringed with demon-like excrescences which tell a sure tale of internal discomfort. Such was the case with that in which my own residence is situated. When I took my house upon lease, though it had been well built by an eminent architect for his own use, yet, in common with all its neighbors, it displayed a grim array of tall-boys and tortuous contrivances as chimney terminals. All these I swept away at once, without inquiry, feeling that, whatever might be needed, they certainly could not be. I then introduced an air-pipe to each fireplace through the floors, and, as I expected, found no smoky chimneys to complain of, though my neighbors still grumble at theirs, as I do of their futile and unsightly expedients to remedy them.

So much depends upon the proper construction of fireplaces and their flues, without which no appliance in the shape of a grate can have fair play, that I shall in the first place describe the points to be attended to in the erection of these portions of a building, and in palliating evils in those which already exist.

The first essential to insure a good draught is that the flue should be sufficiently rarefied. For this purpose it is desirable that it should not be in an outer wall; but, if it be necessarily so, the enclosing wall should be thick (at least 9 in. between the flue and the outer air) or else it should be protected by a double casing, with intermediate hollow space. Materials which absorb damp should be avoided for the construction, as they tend to the evaporation and loss of the heat generated; and the interior of the flue should be well pargetted, to further prevent the suction of external cold by the up-draught within. Another important point is that the flue be not too large, or currents of cold air descending will interfere with the ascending heated air. In old buildings flues are found of large size—as 18 in. by 12 in.—with wide throats, funnel-shaped, diminishing upward. But the fuel used in them was wood, and abundant, and men were more hardy, and minded not the roaring of wind in the chimney, or cowered over the embers within the vast embrasure of the fireplace, which formed an inner room of itself. There are those who would revive these large flues, on the ground that no cowls decorate their terminals. If, however, we are to recur to the practice of our ancestors, we might as well revert to that of a still earlier age, when the stately hall of Penshurst had its fire upon a hearth in the centre, and the graceful wreaths of smoke thence found exit by the lantern in the roof. We must needs then have

the same goodly logs as fuel, and a supply which will enable us to afford the blaze that alone would suffice to rarefy a cavern. The ordinary coal-fires of our apartments do not need a larger flue than a pipe of 9 in. in diameter. Mr. Richardson, in his work, states that the houses built by Cubitt in Belgravia have flues 9 in. by 9 in. only, while others erected later have them 14 in. by 9 in., and that these are distinguishable outside by the absence or presence of objectionable cowls respectively. Kitchen-flues must be larger, in proportion to their fires, or better, perhaps, doubled—a practice for which old precedents may be found, and which seems calculated to avoid down-draughts.

For the avoidance of that particular nuisance, however, special provision should be made in every flue. This may be done by an enlarged space, wherein the force of gusts of wind may expend itself upon, as it were, a cushion of air. If the first pipe above the chimney-mantel be a 9-inch pipe, let the next be a 15-inch one, and the flue above continued with 9-inch ones. A somewhat similar arrangement has been proposed by Mr. Boyd for brick flues. He discontinues the vertical flue a few feet above the mantel with an enlarged space or pocket, and carries an inclined one from the fireplace into this on one side, and the down-draught, thus meeting resistance at the bottom, eddies round the space, without being able to check the upward draught from below. Mr. Cubitt's continuation of the flue to the basement also obviously affords a resisting column of air to accomplish the same purpose. It may be impossible to make such cavities large enough to overcome the effect of every down-draught, but these provisions against them will generally secure this desired end if combined with ample provision of air to the fireplace.

The use of pipes for the lining of flues has the advantage of compelling a good and non-porous finish, which would otherwise be neglected by careless workmen, who often will not take the trouble to properly parget and core the flues in stone and brick walls. The interior of the pipes, however, should be rough, and by no means glazed, or their inability to give any means of adherence to soot will be found a nuisance, in consequence of its continual dropping. The old funnel-shaped throat left a large space above the grate filled with cold air, which checked the draughts. This depends much upon the grate itself; but, generally speaking, the flue should be contracted to its smallest size as soon as possible above the mantel. Iron frames for this purpose, serving as mantel-bars as well, such as Gibbs's registered fireplace-lintel, are useful appliances. A concrete block may be made of the shape required at perhaps the least cost. . . .

The construction of the fireplace itself is of the most importance. The contraction of the flue immediately over it is the first point to be looked to, and next the provision of a proper supply of air for the combustion of the fuel. To illustrate this in the simplest manner, I may refer to a small room with a large fireplace in it, belonging to a friend,

which was complained of as simply uninhabitable by reason of the draughts that invaded it from all sides. A piece of iron pipe, with the lower end protruded through the outer wall, the middle brought through the fire, and the upper end open to the room, stopped all cause for complaint. The reason for this is so obvious that it seems hardly credible that a vast majority of dwellers in houses are enduring continual torture for want of this pipe or some equivalent simple appliance. One looks in vain along the walls of our streets for any signs of air-bricks or other inlets of air, and, with closed doors and plate-glass windows, one wonders where the air comes from to feed the fires within. There are but few available sources, which are these: 1. The joints of the window-frames and chinks round doors, through which cold blasts whistle as they are sucked in, so that these are pasted up, and as far as possible this means of supply intercepted. 2. Unused flues of other rooms down which air pours mixed with smoke; and 3. The soil and waste pipes, the water in the taps of which cannot hinder the precious element from coming even by such undesirable channels, in obedience to the powerful suction of the several fires in the house. These failing, there are positively no other sources. Then, fortunately, the fires begin to smoke, and doors and windows are perforce opened to abate that by far the smallest and least dangerous nuisance of the whole.

The remedy for this is to provide a sufficiently ample supply of pure, fresh air in such a manner that it may come in moderately warm, and from such quarter that it be felt as a draught. There are several means of doing this, each hotly maintained by its partisans to be the only fit and proper one. The bottom, the centre, and the top of the room, are each pointed out as being specially adapted for the purpose by those much-enduring laws of Nature, and the course of the currents of air, demonstrated by flights of the most obedient and flexible arrows. This certainly may be taken for granted: if openings be made in any or all of the positions indicated, the laws of Nature will make a beneficial use of them, but it will be capriciously, one moment as an inlet and one as outlet, as the occasion may need. The fire being the motive power of the currents, the direction that the air will take if it can will be in a straight line to the fireplace, and, therefore, to obviate disagreeable draughts, the air-inlets must not be placed so that currents thence must necessarily impinge upon the inmates of the room, as in the case of the undesigned ones of the chinks round the doors and windows. Again, they should not be so near and below the grate as to rush direct to feed the fire, and thus, not only not aid to ventilate the room, but absolutely take from the fire that valuable office. By far the best mode, in my opinion, is to introduce the air below the hearth, and carry it thence through warming-chambers at the back or sides of the grate, and allow it to issue into the room above the fireplace, or from the outer sides from the chimney-piece, so that it must

ascend and mix with the air in the room before it finds its ultimate exit by the fireplace or outlet-flue. In fact, the fireplace itself should be the fountain of warmed fresh air to an apartment, since no draught thence can be annoying to any of the inmates of the room. The air may be brought, according to its position upon different floors, from below, by air-bricks inserted in the walls between the joists, or from above the roof by a flue constructed for the purpose; and if this flue be carried in close connection with the chimney-flue, whether in separate pipes, as by Mr. Jennings's method, by the use of Boyd's metal withes, or ordinary brick ones, the air drawn down by the suction of the fire will have the temperature considerably raised above that of the outer atmosphere, the coldness of which, entering by windows, is unendurable.—*Builder.*

IS ELECTRICITY LIFE?

By HENRY LAKE.

WE have had many specimens of electricity this summer—more, perhaps, than for fifty years previously. Those, particularly, who lived in the north and west of England, have had a greater demonstration of the powers of this extraordinary agent than in any ten years, rolled into one, of the last quarter of a century. The thunder season began with five days' successive storms in Liverpool and its neighborhood. The first arrived on Monday, soon after the fire which broke out at the Northwestern Hotel had frightened the people half out of their senses. The storms culminated on Thursday, when the fire literally "ran along upon the ground," and the thunder bellowed in the ears of the merchants, so that business was suspended and "high 'Change" was a desert at mid-day. Fortunately, the only serious result was the firing of a house at Birkenhead, stunning the lady inmates, knocking down the chimneys, fusing the bell-wires, and melting the gas-pipes. After a few discharges here and there, with more or less injury to life and property (notably in Manchester), the atmosphere became wonderfully settled, and Monday, the 17th of June, was one of the finest days, and one of the calmest and brightest evenings amid the usual long twilight of the North. Those particularly who were travelling at that time will not soon forget that extraordinary evening, when, by the most peculiar clearness of the atmosphere, every object was brought out with a sharpness which rendered the whole landscape a new sensation. It was the quiet rest of Nature before the battle of the elements which was to follow.

The 18th of June will long be remembered by all the people of the north of England. An Egyptian darkness came down upon the land

at mid-day. While the sun was shining, the lightning fired the electric gun at Newcastle three minutes before its time, casting a slur on the chronometer of the best ship lying in the river; and then, like a pall, the clouds descended and literally walked through the town. There was no looking *up* at the lightning; it was on a level with the eye. The streets were a deluge, and old people and children and furniture were hurled along in the torrent. At the height of the storm, twenty-one flashes were counted in a minute, and the thunder rolled without intermission, only enlivened by a loud discharge as from a sixty-four pounder. Wherever there was a window open, the lightning ran in and out in mad revel. Houses were struck in every direction, and windows of whole streets were smashed, though no one knew whether by the hail or the thunder. Families assembled for prayer, believing they had arrived at the final consummation; and all who witnessed this storm—whether the population, scared out of their wits for many a day, or the fifteen people who were struck by the lightning, or the five who were killed by it (if they could have returned to give their testimony)—would have decided the question at the head of this paper, and said, "Electricity is *death*."

And yet "electricity *is* life." It is the very soul of the universe. It permeates all space, surrounds the earth, and is found in every part of it. Its pristine character is by no means what we have above described. It is naturally the most peaceful agent in creation. It is eminently social, and nestles round the form it inhabits. Unlike many human specimens, it never desires to keep all its good to itself, but is ever ready to diffuse its beneficence. It is only in abnormal conditions, and in unexpected *rencontres*, that it displays itself in that brilliant flash and that deafening roar with which its majestic force yields up its great spirit.

The ocean, for instance, is compounded of water and salt; one is an electric, the other not. The friction of these causes the phosphorescent appearance so often observed at sea. But, when clouds arise from the ocean and come inland, they are mostly highly charged with electricity, and, being naturally anxious to give up the good things they possess, when they meet clouds not so much electrified, they hand over their surplus commodity, and the deliverance makes the earth and all created things in the neighborhood tremble. Or, if clouds arise from fresh waters, or from land not having much electric fire, the sun himself warms them up in a friendly manner; and, as they become charged with the vital fluid, and, in a drunken sort of way, stumble against the sides of mountains or against other clouds, the same benignant tendency to part with what they have too much of induces them to give up their vital force, and the fire flashes across the sky, and all creation bows before the artillery of the heavens. And then they weep together over the kindly exchange, though their tears do sometimes swell the rivers and produce a number of catastrophes not originally in the pro-

gramme, as at Manchester and throughout Yorkshire this season; and their friendly distribution of fire sometimes fails to reach the intended cloud, and strikes down towers, churches, trees, and houses, and occasionally destroys a human body not possessed of its proper quantity of electricity. For that is, most probably, the reason why we so often find one person struck by lightning in a place where several others are assembled and escape.

A singular instance of the friendly interchange of civilities among clouds was observable at Bridlington Quay this summer. Those who know the place will remember the long stretch of table-land lying north and south, and facing the ocean. A large cloud over the sea lowered and approached the south point of the table-land. Immediately a flash ascended from the earth to the cloud, and this again occurred more than twenty times as the cloud sailed majestically over the fringe of the table-land from south to north. And now overhead might be seen a succession of minor clouds, arriving from all directions, but all evidently having their eye upon the big cloud that was approaching them, until they hovered round it like a parcel of school-boys round a newly-arrived cake. At length the cake was cut. A flash came out from the big cloud, then another and another; then the nearest clouds flashed out again to those which were farther removed. Down came a deluge of rain, the thunder rolled incessantly, till, the distribution of good things having been completed, the clouds sailed away, and the sun shone again merrily.

That all created living bodies are electric there can be no question; and as little that some persons, animals, and plants, are more electric than others. Two forms of the latter are familiar. Few school-boys are guiltless of experiments on poor puss, from whose much-enduring back electric sparks may be drawn, especially in dry, frosty weather; and most young ladies have admired the elegant sensitive-plant, whose leaves seem to move and feel,

> "And with quick horror fly the neighboring hand"

that draws from it the electricity which it contains more than other plants; and its leaves at once fall flaccidly, until a new supply of electric force renders them once more turgid.

But bodies have not only electricity within them, but an electric atmosphere, of the form of the body which it surrounds, and which is attracted by it. Without this, we could not shake hands with a friend, or kiss a lip, without the danger of the excess of electricity flying off and destroying us, or the he or she that we would greet or kiss. Perhaps it is the commingling of these electric atmospheres that makes kissing so nice.

Two conditions of the human body are also illustrative of its varied electrical action. A person who has the small-pox cannot be electrified, while sparks of electricity may be drawn from the body of a patient

dying of cholera. In the first instance, it appears that the body is fully charged with its own electricity, since it is impossible to electrify a body beyond a certain degree; in the latter, there seems to be a tendency to part with the electrical force which is essential to the support of life, and which may account for the distressing and rapid weakness of cholera patients.

We have hitherto spoken only of electricity of very high tension, which produces the lightning-spark; and which boys and girls know as the product of the frictional electrical machine, the shock of which their elbow-joints constantly remember. We wish now to refer to something infinitely more quiet and peaceful, and to which we are indebted for many of our greatest luxuries.

Galvani's boy-pupil, amusing himself in his master's laboratory, accidentally bringing the legs of a recently-killed frog into an electric current, the great philosopher perceived at once the manifestation of a new power. It remained only for Volta to invent his pile, consisting of a continued series of zinc and copper plates, with pieces of cloth between, and the foundation and general principles of electro-galvanism and voltaic electricity were laid down.

Frictional electricity has been compared to the high-pressure steam of a locomotive, and voltaic electricity to the steam rising quietly from an open boiler. The chemical action of frictional electricity is very feeble; it has great intensity but little quantity; while the voltaic pile will yield an enormous *quantity* of electricity but with feeble *intensity*. Faraday calculated that it would require a Leyden battery to be charged by 800,000 turns of a powerful plate machine to decompose a single grain of water, which by one of Pulvermacher's bands may be done in a few seconds.

It is to this latter agent, voltaic electricity, that we are indebted for electro-plate, which has not only rendered our tables more decent, but has supplied real works of art, and statues and ornaments innumerable. That is also the power by which we are enabled to convey our thoughts thousands and thousands of miles, over mountains and through vast oceans, and to converse from our dining-room with our friends in almost every part of the world; while by its agency rocks are blasted, cannons and torpedoes are fired, and even the bells of some of our houses are rung.

Undoubtedly, however, the greatest marvels of this beneficent agent are to be found in its influence on the human frame, and in the cure of disease. But, like every thing that is destined eventually to be accepted by the public as a matter of course, it has had to pass through the usual three stages of contempt, controversy, and adoption. More than a hundred years ago John Wesley said: "How much sickness and pain may be prevented or removed, and how many lives saved, by this unparalleled remedy! And yet with what vehemence has it been opposed! Sometimes by treating it with contempt,

as if it were of little or no use; sometimes by arguments, such as they were; and sometimes by such cautions against its ill-effects as made thousands afraid to meddle with it." And he thus sums up his opinion of the medical profession, and their opposition to the use of electricity in disease: "There cannot be in Nature any such thing as an absolute *panacea*, a medicine that will cure every disease incident to the human body. If there could, electricity would bid fairer for it than any thing in the world. Mr. Lovett is of opinion that the electrical method of treating disorders cannot be expected to arrive at any considerable degree of perfection till administered and applied by the gentlemen of the faculty. Nay, then, *quantâ de spe decidi!* all my hopes are at an end. For when will it be administered and applied by them? Truly *ad Græcas calendas*. Not till the gentlemen of the faculty have more regard to the interest of their neighbors than their own. Therefore, without waiting for what probably never will be, and what indeed we have no reason to expect, let men of sense do the best they can for themselves, as well as for their poor sick helpless neighbors. I doubt not but more nervous disorders would be cured in one year by this single remedy, than the whole English *materia medica* will cure by the end of the century."

This is hard upon the doctors, yet it only fairly expresses their conduct at that period. They alone, however, are not to be held responsible for the delay in adopting the curative powers of electricity. Every thing worth having has to force its way to acceptance. A popular writer has well said: "If London could be lit, like the city in the fairy tale, with a single diamond, which rendered it brighter at midnight than at mid-day, it would take ten years to smoothe away prejudices and conciliate self-interests, so as to admit of the illuminating gem being displayed." All the astonishing cures in the early period of electricity were effected by clumsy and unportable machinery, with "shocks" of high-tension current, which are peculiarly disagreeable to some persons. They are indeed like the actual cautery—the hot iron to the wound—when compared with the modern appliances of chain batteries and bands, whose action is so tender that a baby would not wince at it, and which are so portable that the whole apparatus may be carried in the pocket. It has fallen to the man of science, and not to the medical practitioner, to enforce a belief in the curative powers of electricity upon the public.

About the centre of the fashionable side of Regent Street may be seen the establishment of Mr. Pulvermacher. How many suffering from disease which has baffled the skill of physicians, how many whose nervous feelings render life a burden to them, how many afflicted with tic-douloureux or neuralgia, limping with gout or rheumatism, shivering with palsy, or bent with paralysis, pass that establishment, ignorant that therein most probably lies the mitigation of their suffering, if not their absolute cure!

There can be no question of the curative powers of electricity, since there is now extant a scientific literature, by the most eminent physiologists and thaumaturgists, affirming these powers; but, as we have said, electricity has been clumsy in its apparatus, and unpleasant in its action. These difficulties Mr. Pulvermacher has effectually overcome, to the satisfaction not only of most of the scientific men on the Continent, but also of such men as Sir C. Locock, Sir H. Holland, Sir William Ferguson, Sir J. R. Martin, Dr. Sieveking, Dr. Quain, Dr. Andrew Clarke, Dr. Golding Bird, Dr. Thompson, and a host of other English celebrities.

The great advantage of electrical action is, that it brings relief in a large number of diseases confessedly beyond the reach of the ordinary remedies of the physician. How powerless, for instance, is ordinary medical skill in tic-douloureux! Tic, tic, tic; it is a recurring gentle monosyllable, suggestive of something peculiarly quiet and peaceful; but, madam, that tic shoots through your head like a shot from a nine-pounder, the only difference being that after the "tic" you have your head ready for another, while after the shot you would have no head worth mentioning. Or, see the tears rolling down the cheeks of that pretty girl, whose ideas of love and romance and sentiment are scared away by the wearing pain of neuralgia; or, racking with the pain of gout and rheumatism, the man of middle age passes his restless nights, gaining temporary respite from pain by colchicum, or a fitful repose from morphine, and buying present ease at the cost of an unhappy and painful old age. Why, madam, do you endure this tic? Why, dear young lady, do you pine under neuralgia? Why, old man, do you writhe in gouty or rheumatic agony, when help is so near? It is the *vis inertiæ*, the unbelief in the face of facts, the idiotic negligence of remedies which appear simple. If they had been bid to do some great thing, would they not have done it? But these little chains, that can be worn like a piece of ribbon, what are they in the face of tic, and neuralgia, and rheumatism? These chain-batteries, that look like pieces of jewelry, what can they do to strengthen the trembling hand, or revive the withering limb?

We will tell you what they are, and what we have seen them do. We have seen this little band, which you seem to think so little of—you, the sufferer from acute pain—we have seen it with only four or five elements—that is, about a foot long—dry and unexcited, placed for one second to the upper plate of an electroscope, and it has produced the phenomena of attraction and repulsion on the gold-leaf. We have seen a band half an inch wide prove the power of the electric current, by passing through two persons and decomposing water in a test-tube. We have seen the little glittering chain-battery, which could be carried in the waistcoat-pocket, produce a continuous current that diffused a perfect glow of warmth through the system; and with a little instrument, called a "contact-breaker," appended to the same

chain, we have had the intermittent current, which can be regulated, from a gentle vibratory motion to shocks as powerful as could be gained from a huge or cumbrous battery, and far more powerful than we cared to endure.

But, if these chains and bands are small, they are not only powerful but valuable; and, as money is the great test of value in this eminently commercial country, it may be right to state that £10,000 was the penalty inflicted by the Imperial Court of Appeals in Paris, for the infringement of the patent.

Here, then, we have an electric source divested of all machinery and complication, which could be carried in a cigar-case, and which can be made to furnish both the interrupted and the continuous current in large quantities. It can be set in action by the simplest means —merely a little vinegar and a little water; and it can be applied not only, as in the old mode, to the extremities, but so as to surround the body of the patient.

Although we are not continually made sensible of it, men and women are electrical machines. The researches of Matteucci, Dubois-Reymond, Rutter, and Faraday, prove that there exists, both in the muscles and nerves of human beings and all animals, a natural electricity, independent of mechanical, physical, or chemical actions, exterior or interior; that this electricity is manifested under the form of closed currents circulating along the muscles or nerves; that the presence of this free electricity is subordinate to the state of the life of the animal, and disappears with the vital force; that all parts of the body furnish signs of free positive electricity, especially when the circulation is excited, which signs disappear under the action of cold and in rheumatic fever; that quantity currents of low tension are constantly acting throughout the vascular system, while currents of high tension, but of inferior quantity, are to be found in the cerebral, spinal, and nervous systems, flowing, in a state of rest of the individual, in directions defined by Nature, from the centre to the circumference.

The direction of this current is modified by voluntary muscular contractions, but its flow may be obstructed by hostile, poisonous influences. A deficiency of the powers of the body for this electro-generation, or a deficiency in the conducting powers of the vascular and nervous systems, is to be remedied by an artificial supply of electricity, precisely as we go to the fire to warm ourselves. But, precisely as we do not put ourselves on the fire, but take its heat steadily and lastingly, so we do not now take a dose of electricity sufficient to shake us to pieces, but, by these chains and bands, keep up and sustain a genial warmth of the parts affected, or of the whole system. Nor is there the slightest inconvenience in wearing the bands, which are made to fit any part of the body, or to surround it altogether, as is advised in cases of general weakness. Having once been wetted with vinegar-and-water, the action commences, and the moisture of the body is suffi-

cient to sustain the excitation of the chain or band for an indefinite time. That the current does exist, even in its dry state, we have already shown by the test of the electroscope.

An interesting experiment, showing the electricity of the human frame, and bearing strongly on the importance of these inventions for restoring the lost or suspended electric powers, was made by Mr. Rutter, of Black Rock, Brighton. Having brought the two ends of the conducting wires of a galvanometer into two basins of water, a lady, acknowledged to be in consumption, placed a hand in each basin, and grasped two pieces of wood—with the left hand lightly to complete the contact, while her right pressed the wood firmly with muscular contraction. The needle of the galvanometer at once deflected from twelve to fifteen degrees, but in a few moments came back to zero; and no muscular effort on her part could deflect it. A stalwart blacksmith was then brought in and the same experiment tried, but with all his muscular contraction the needle was only deflected about 5 degrees. He was then made to give 25 strokes on an anvil with his sledge-hammer, and when he afterward repeated the experiment the needle deflected at once 12 degrees.

By this experiment two things are shown—that, in a state of disease, the body readily parts with, or rather has not the power to retain, its electricity; and that, in a state of health, muscular exertion of considerable severity is requisite to cause it to pass out of the system. There is just room, however, in this experiment, for the captious spirit to object that some chemical action took place by the use of the water. Mr. Pulvermacher has improved on the experiment, by using simply two metallic handles of the same kind of metal, when precisely the same effect is produced upon the galvanometer.

It was suggested, in 1850, by the writer of this article, that the proximate cause of cholera might be found in the rapid passage of electricity from the human frame; the peculiarity of the atmosphere, known to exist during cholera, favoring the passage of that which is the life itself to the human system.

Since that time, wonderful cures of cholera have been recorded by Dr. Godwin, of Elbœuf, Dr. Defontaine, of Mons, Dr. Atkinson, and others. The latter, on one of his cases, remarks: "It was indeed singular to notice the visible quantity of electric fluid which continually discharged itself on the approach of any conducting body to the surface of the skin of a patient laboring under the collapse stage." M. Andraud states that at the height of the epidemic in Paris, in 1849, it was impossible to obtain from the electrical machine any thing but slight cracklings without sparks, and on the 7th of June it was quite dumb. He continued his observations, and on the 9th the machine at the least touch rendered with facility most lively sparks. It is remarkable that, in the six days following the 8th of June, the mortality in Paris fell regularly from 667 to 355.

It is now only about 150 years since electricity was discovered, not more than 120 since the discovery of the Leyden jar enabled electricians to concentrate the vital fluid. What has it not done for us in that time! And while it was so decried at first, and has met with impediment after impediment, we now accept what it gives us, so quietly and so much as a matter of course, that a few days ago the announcement that electric communication was completed with the antipodes called forth nothing more than a short paragraph in the newspapers. May we not hope, then, the time has come when not only the scientific medical man, but every practitioner, will look for himself into the curative powers of electricity?

Every thing that is good, however, in the present day is sure to have a host of empirical imitators, and the inventions of which we have spoken are no exception to this rule. These chains and bands are really formed on scientific principles, giving the patient the benefit of the curative powers of electricity in a convenient form. There are many spurious appliances under the name of magnetic, electro-magnetic, and other high-sounding titles, that get confounded with the continuous current of electricity, which alone, in the opinion of the highest medical authorities, can have any effect on the diseases we have enumerated. The mischief done by these spurious imitations is incalculable, and they lead, not only to disappointment, but have a discouraging effect upon the public mind.

Judging by the extraordinary cases of cure by the use of these chains and bands, now well authenticated by the highest professional authorities, John Wesley was indeed prophetic when he wrote in 1759: "It is highly probable a timely use of this means might prevent, before they were thoroughly formed, and frequently even then remove, some of the most painful and dangerous distempers—cancers and scrofulous humors in particular—though they will yield to no other medicine yet discovered. It is certain nothing is so likely, by accelerating the contained fluids, to dilate and open the passages, as well as divide the coagulated particles of blood, that so the circulation may be again performed. And it is a doubt whether it would not be of more use, even in mortification, than either the bark or any other medicine in the world."—*Belgravia.*

DO BIRDS IMPROVE IN NEST-BUILDING?

TRANSLATED FROM THE REVUE DES DEUX MONDES,

By J. FITZGERALD, A. M.

"A MAN'S house," says a learned hygienist, "is but an extension of his clothing: the tent is next-door neighbor to the mantle, and the roof is simply a big head-gear." A house, just like the clothes we wear, is, first of all, a shelter to protect us against the medium

around us, and to shield us against the inclemency of the seasons. The animal, in this happier than man, has no need of dress—Nature supplying it with plumage or with fur—but yet is required to build for itself the dwelling-place where it is to find shelter. May we suppose that here, too, Nature provides for every thing, and that blind instinct guides the bee in the construction of her cell, and the bird in the building of its nest? Such, indeed, is the opinion of most naturalists, and their chief argument is drawn from the fact that birds always follow the same plan in building their nests, while man is ever modifying and improving bit by bit his methods of construction. But, now, is this argument based on unquestionable facts, or is the conclusion legitimate? An English naturalist, Mr. Alfred Russel Wallace, undertakes to prove the contrary, in his work on Natural Selection. According to him, the bird does not build its nest by instinct; and the mental faculties it exhibits in this operation are of an identical order with those exhibited by man when he builds a house. In short, it is claimed that these faculties are simply imitativeness, and a sort of rudimentary ratiocination, which can take account of external surroundings, whatsoever they may be. Hence it is that birds do change and improve their processes of construction, under the influence of such causes as determine progress in man; and, in turn, man is at a stand-still when he receives no impetus from without.

What is instinct? It is "the faculty of performing complex acts, absolutely without instruction or previously-acquired knowledge." Instinct, then, would enable animals to perform spontaneously acts which, in the case of man, presuppose ratiocination, a logical train of thought. But, when we test the observed facts which are usually put forward to prove the power of instinct, it is found that they are seldom conclusive. It was on such grounds that the song of birds was taken to be innate, albeit a very ready experiment would have shown that it comes from the education they receive. During the last century Barrington brought up some linnets, taken from the nest, in company with larks of sundry varieties, and found that every one of his linnets adopted completely the song of the master set over him, so that now these linnets—larks by naturalization—formed a company apart when placed among birds of their own species. Even the nightingale, whose native song is so sweet, exhibits, under domestication, a considerable readiness to imitate other singing-birds. The song of the bird is, therefore, determined by its education, and the same thing must be true as to nest-building. A bird brought up in a cage does not construct the nest peculiar to its species. In vain will you supply all the necessary materials: the bird will employ them without skill, and will oftentimes even renounce all purpose of building any thing like a nest. Does not this well-known fact prove that, instead of being guided by instinct, the bird *learns* how to construct its nest, just as man learns how to build a house? This observation might be made complete, if we were

to shut up in an enclosure, with a wire screen overhead, a pair of birds brought up in isolation from their kind, with a view to find out what manner of nest their inexperienced efforts would produce. But, even though we have not such evidence, there are plenty of other proofs which confirm Mr. Wallace's theory.

The form and structure of birds'-nests are more dependent than is usually supposed upon external conditions, and consequently they vary in proportion as these conditions are changed. Each separate species employs the materials it has at hand, chooses sites most agreeable to its habits; and the shape given to the nests often betrays very definite purposes, which are not to be detected without some degree of discernment. The wren, which dwells in hedge-rows and thickets, commonly builds its nest of the moss in which it is accustomed to search for insects; but at times it departs from this custom, and employs feathers and hay, when they are to be had. The raven, which feeds on carrion, frequenting pasture-grounds and warrens, builds its nest of wool and fur; the lark builds in a furrow, employing dry twigs, interwoven with fine blades of grass, which it collects when looking for worms; the kingfisher uses the bones of fishes he has eaten. The long-legged and big-beaked flamingo, which stalks about in wet flats, builds a conical hillock of mud, and in this deposits her eggs, so as to sit easily upon them, and to keep them out of the water.

In what respect are these animals, which avail themselves of the circumstances around them for a perfectly determinate object, inferior to the Patagonian, who builds for himself a rude shelter of foliage; or to the African negro, who scoops out a hole in the ground? It will be said that man progresses: but that is not universally the case. What progress is shown in the palm-leaf huts of American savages, the tent of the Arab, the Irish mud-cabin, the stone hovel of the Scottish peasant, which appear to belong to primitive times? The art of house-building remains stationary, if it is in conformity with tastes and habits which are unalterable, because the physical conditions which determine them are ever the same. Sometimes even a habit once engendered persists, though the exterior conditions be changed. The Malays from time immemorial built their houses on piles, after the manner of the lacustrine dwellings of ancient Europe; and this mode of building has sunk so deep into the manners of tribes which have penetrated into the interior of the islands and settled on arid plains, or on rocky mountains, that they still go on prudently raising their houses above the surface of the ground. And yet, no one imagines that in these inveterate habits we have a case of instinct; and certainly no one would suppose that an Arab infant brought up in France would feel the need of dwelling in a tent of skins, or that a young Malay, if brought to Europe, would bring with him his habit of building on piles. The unvarying processes of barbarous tribes are

explained on the theory of a secular tradition, untroubled by any external influences.

But why not apply the same reasoning to the facts presented to us by the animal kingdom? The processes of nidification are determined by the physical circumstances, as well as by the conformation of the nest, and by the tools supplied by Nature, and they are modified in accordance with external conditions. An alteration of climate, any sensible change in the vegetation of a country, the introduction of new enemies, bring about architectural variations more or less marked. Several birds prefer the ends of threads which they pick up on the streets to the vegetable fibres used by them before, and of their own accord take up their quarters in boxes or hollow gourds arranged for their use, thus saving a part of their labor. The common sparrow readily adapts himself to circumstances: he takes far less pains with his work when he can avail himself of a nook in a wall, than when he is obliged to build in the open air, on the branch of a tree, for then his nest must be solidly built and well covered. The orchard oriole or bobolink, of the United States, builds his nest almost flat when he can fasten it on a stout, stiff branch, but far deeper when he has to hang it on the slender branches of the weeping-willow, where it may be swayed by the wind, and the chicks thrown out. Finally, M. J. A. Pouchet published, in 1870, some very curious observations on the progressive improvement of martins' nests. He kept for 40 years in the Rouen Museum some of these nests, which he had himself detached from the walls of old buildings in that city. Having one day got some new nests, he was amazed, on comparing them with the old, to perceive considerable differences. The new-style nests all came from a new quarter of the town, and were all built on the one plan; but on examining churches and other ancient buildings, as also certain rocks inhabited by martins, he found several nests of the old pattern, together with others constructed according to the more recent model. The figures and descriptions given by old naturalists portray only the primitive type, which is a quarter-hemisphere, having a very small circular orifice. The modern nest, on the contrary, has a width greater than its depth, and forms a segment of an oblate spheroid, the orifice being very wide. Here we see an evident progress, the new type being larger, more *comfortable*. The wider bed gives the chicks greater liberty of movement than they had in the deep and contracted nest of former times; the wider opening allows them to look out and take the air; in short, it is a sort of balcony, where two chicks find room without being in the way of the old birds. Nor is this all. Being situated nearer to the top of the nest, the opening is less exposed to rain and wind. One well-proved case of this kind is enough to show that the architecture of birds is susceptible of progress; and this would seem to overturn the hypothesis of blind instinct. Then, too, the evident imperfections observed in the nests of some species, and the awkward-

ness, not to say stupidity, of some birds, cannot be reconciled with the theory of infallible instinct.

To conclude, then, the nidification of birds exhibits phenomena which, if compared with the constructive processes of primitive man, show no essential difference in the nature of the faculties employed. We have here no innate ideas, or blind and irresistible tendencies. The bird learns how to build its nest, and each species has its own tradition, which can be modified according to external circumstances. As regards the origin of these constructive processes, it can be readily understood without supposing a special instinct, if we show that, at bottom, these processes are simpler than at first sight would appear. For we must not exaggerate the grade of intelligence needed by a bird in order to build a nest which to us appears simply marvellous, because it is so small. But this nest was first roughed out—twig on twig, fibre on fibre; next, the little architect stopped up the gaps with material easily brought in with its supple claws and its slender beak. We are charmed at the sight of this; but the rude mud wall of a peasant's hovel would, in the eyes of a giant, also appear to be fine handiwork. It all depends on perspective. Levaillant has observed the habits of an African bird which goes to work in a still more summary way. This bird gets together a heap of moss and cotton, converts it, by stamping, into a sort of felt, then hollows it out in the middle, and trims off the edge. Thus the inside of the nest becomes as smooth and compact as a piece of cloth. Why not admit that this process is the work of an inventor, whose invention benefits his posterity, they in turn improving it, and handing it down to succeeding generations, just as we say in the case of human discoveries, of which we are so vain? In studying the rise of architecture, we meet with many a type which attracts the eye, but which answers but imperfectly the needs for which it was produced, and which shows less rational foresight than do the nests constructed by sundry birds.

THE ANTIPODES AND PERIŒCI.

By HEZEKIAH BUTTERWORTH, Esq.

ABOUT few geographical positions are there more mistakes made by intelligent people than the situation of the antipodes and the periœci. It has been commonly taught in the schools, at least in New England, that the antipodes of the Eastern States, or of dwellers near parallel 40, are in China, and that the antipodes of Boston are in Peking. Of course, this error is not made by the best instructors, but it is often made, and that without correction, in the presence of the "honorable committee." Editors, too, are often as much at fault as

teachers, in speaking of antipodal places. Thus, after the earthquake at Lone Pine, California, and that which destroyed a part of the ancient city of Antioch, the New York *World* published an article on these phenomena, from the pen of a correspondent, entitled "The Antipodes shaking." The editor of the *World* corrects its correspondent, who supposes that Lone Pine and Antioch are antipodal, and says: "A point immediately under Antioch is in the Pacific Ocean, about halfway between San Francisco and the Sandwich Islands." These errors were copied by other papers.

The word antipodes is of Greek origin, from *ἀντί, against*, and *ποῦς, a foot*, and means literally, *with feet opposite*. Hence the Latin word *antipodes*, which is plural, and as a pure Latin plural should be pronounced as in the original, or in four syllables, *an-tip-o-des*. But, as the English word *antipode is* used, the plural of this may be formed regularly in three syllables. This pronunciation is sanctioned by Dr. Webster, and may ultimately prevail. At present, however, the best scholars give the division and the accent of the pure Latin plural.

The word literally signifies, those who have their feet against each other, or, those whose feet point toward each other; that is, those whose feet are *diametrically* opposite. As applied to geography, it means, the dwellers at the opposite extremities of the diameter of the earth.

The periœci, or periecians, are often mistaken for the antipodes. The periœci are the inhabitants on the opposite side of the globe, on the same parallel of latitude. Hence, when people say that the antipodes of the Eastern States are in China, they mean the periœci.

Two antipodal parts of the earth have the same number of degrees of latitude, one north and the other south, unless one of these points is on the equator

Two antipodal points must be on one and the same meridional circle, separated from each other by half the circumference.

Being on one and the same meridional circle, they may differ in longitude 180°, with the exception of the poles themselves, which have no longitude.

And being separated from each other by half the circumference, they must be equidistant from the equator in opposite directions.

The longitude of two antipodal points, if east and west longitude is used, must together make up 180°, or 12 hours, one east, and the other west. The antipodes of a point in 40° north latitude and 60° east longitude are in 40° south latitude and 120° west longitude. The antipodes of a place in the eastern part of the United States, situated on parallel 40° north latitude, and on the meridian marked 7°, must be on the same parallel south latitude, and on that meridian which, added to 7°, will make up 180°, or 173°, which would be in the South Indian Ocean, a point between St. Paul's Island and Van Diemen's Land This point would be antipodal to Boston or New York.

The following principal cities and places in the world are antipodal:

London	Antipodes Island, southeast of New Zealand.
New York	South Indian Ocean.
Lima	Siam.
Nanking	Buenos Ayres.
Quito	Sumatra.
Bermudas	Swan River.
Azores	Botany Bay.

Antipodal places have the same climate, with all of the seasons, days, and nights, completely reversed. When it is noon in London, it is midnight at Antipodes Island; and the noon of the longest day at the Bermudas is midnight of the shortest day at Swan River. When the sun is rising at New York, it is setting on the South Indian Ocean.

Antipodes Island, a small strip of land in the South Pacific Ocean, southeast of New Zealand, is so called because it is the nearest inhabitable point to the antipodes of Greenwich, latitude 49° 32′ south, longitude 178° 42′ east.

We said that the seasons at the antipodes were reversed. Take, for example, New Zealand, which is nearly antipodal to England. New Zealand has one of the finest climates in the world. The summer is a little longer and warmer than in England, the atmosphere more moist, and fogs are frequent. Spring begins in September, summer in December, autumn in April, and winter in June. January and February are the warmest months of the year, while July is the coldest. The flowers bloom in January, and the snow falls in June.

So, in a figurative sense, antipodes means opposite. As Shakespeare says, or makes one of his characters to say, in the play:

> "Thou art as *opposite* to every good,
> As the *antipodes* are unto us."

USEFUL THINGS.[1]

By EDMOND ABOUT.

UTILITY does not require to be defined. Nevertheless, an explanation of it may be profitable.

Many years have elapsed since man appeared on the earth. Geologists affirm that, before our appearance, this little globe moved round the sun for thousands and thousands of ages. During that period the soil, the sea, and the air, were of no benefit to anybody, because no one existed here below. A multitude of plants and animals was

[1] From advance-sheets of the "Hand-book of Social Economy." By Edmond About. D. Appleton & Co.

created before the germs of the first men were formed: these plants and animals, whatever properties and powers they might have had, were entirely useless, because utility, as we understand it, means the service which a thing might render to man; therefore, there was nothing useful prior to man's advent in the world.

Man is born, and all beings at once take rank in relation to him. The wild beast, rushing to devour him, enters into the first category of noxious things; the poisonous plant reveals to him its baneful properties; the thorns which prick his limbs, the insects which prey on his body, are noxious to him in degrees varying according to the amount of pain which he suffers or dreads.

The timid animals that flee before him, the plant which neither injures nor nourishes him, the hidden mineral lying in unseen veins under his feet, are all either unimportant or useless.

The useful is that which makes man's life more easy or more agreeable. But we have agreed, in the hypothesis of the shipwrecked sailor, that Nature by herself supplies us with very few useful things. Excepting the soil which sustains us, the air we breathe, the water we drink, there is nothing which, to my mind, is due to her.

Our first resources, or, more properly speaking, all the gifts of humanity, are the conquests of labor.

Man can neither create nor destroy an atom of matter, yet he can assimilate and identify himself with whatever suits him; he can turn aside whatever menaces him; above all, he can adapt for his use and employ for his profit, that which was originally valueless or even dangerous. By means of labor he impresses the stamp of utility upon all he touches, and thus little by little annexes, as it were, the entire earth.

Utility proceeds from and returns to man. If we do not create things themselves, we create their usefulness. But that costs something. Nothing is got for nothing. We are not Nature's spoiled children. After man was created, he appears to have been told: "I leave you to yourself. Whatever you produce is your own."

Do you wish to see by some examples how man does his part and becomes the producer of utility?

If, on leaving home an hour hence, you meet a lion at the bottom of the stair, should you hesitate for an instant in regarding it as a noxious animal? Is not this true?

However, thanks to the strenuous exertions of several generations, lions, driven from Europe, have now no abode save Africa. The distance which separates you from them enables you to think of them with indifference.

When an agile, a brave, and skilful man succeeds at the risk of his life in accomplishing the trifling task of lodging a ball between a lion's eyes, the animal is no longer noxious, nor even indifferent and useless. Its skin is worth 100 francs; it will make a rug.

Suppose that, instead of shooting the brute, a prudent hunter, by

means of greater strategy, should entrap and imprison it in an iron cage and bring it to Marseilles! The lion disembarked at the dock would fetch many thousand francs.

If, by means of still more skilful and longer-continued labor, a lion-tamer, like Batty, subdues the dread monster, the lion would fetch thirty thousand francs at least. Nature creates a devouring animal: human skill converts it into a bread-winner.

The whole race of domesticated animals in man's service, yielding him eggs, milk, wool, and even flesh, was wild at first, that is to say, was so far separated from, as to be of no use to him. By his skill he not only tamed these animals, but, as it were, he has modified and remodelled them after a pattern supplied by himself.

Man fashions at will draught-horses and racers, oxen for the plough and oxen for the table, sheep which furnish wool and sheep which furnish tallow, fowls which lay eggs and fowls which are fitted for the spit, fat pigs and lean pigs: from one breed of dogs, man has produced the greyhound and the bull-dog, the setter and the harrier, the pointer and the lapdog. When you go to an exhibition of any sort of live animals, remember that art has as great and Nature as little a share in it as in an exhibition of pictures.

Apply the same method of reasoning to all agricultural, arboricultural, and horticultural exhibitions. Neither our gardens, our fields, nor our woods, are masterpieces of Nature, as is ignorantly said; they are masterpieces of human industry.

All double flowers, without exception, are man's work. Pluck a wild rose from a hedge-row, and then go and see a collection of Verdier's roses: you will learn how much Nature has bestowed, and what man has made of it.

All the pulpy and juicy edible fruits are man's work. Man went as far as Asia, and even farther, in quest of the coarse products which resemble our peaches, our cherries, our pears, as much as the wild-rose resembles the "Palace of Crystal" or the "Remembrance of Malmaison" rose.

Each of our vegetables represents not only distant voyages, but also centuries of skilled labor and assiduous elaboration.

It was not Nature that gave the potato to the poor of our land. Human industry went in quest of it to America, and has cultivated, modified, ameliorated, varied, and brought it step by step to its present state, accomplishing the result in less than a century. Yet to this century of culture must be added the prior labor bestowed on the plant by the natives of America. When the products of a distant country are brought to us, we are prone to believe that Nature alone has done every thing. But, when the Spaniards discovered America, it had been cultivated from time immemorial. Hence man had turned Nature to his advantage there, as well as in Europe and elsewhere.

Wheat, such as we see it, is not a gift of Nature. It grows spon-

taneously in Upper Egypt, yet there it yields but a poor and miserable seed, unfitted for making bread. Many ages and a prodigious expenditure of labor were required in order to develop, swell, and perfect the seeds of this useful food for man. Have you ever been told that wheat is distinguished from other cereals by its containing a notable proportion, sometimes a quarter, of nitrogenous substances? This valuable gluten represents the blood and flesh of thousands of generations that perished in the culture of wheat.

While labor supplied the most precious of its useful properties to this grain, of which each of us consumes three hectolitres yearly, pharmacy altered the use of fifty vegetable poisons, and converted them to the profit of our species. Not merely does man add a portion of utility to that which possesses none naturally, but he turns bad into good.

During how many ages did the electric fluid hold a place among the number of curses! We knew it only by the dreaded effects of lightning.

Franklin discovered the lightning-conductor, and conferred on everybody the means of neutralizing this great curse. A force, eminently mischievous, becomes indifferent to the man who is prudent and wise. Security during a storm is henceforth the price of easy and inexpensive labor.

But does man halt in so fine a path? No. Hardly has he conquered this hostile power, than he undertakes to domesticate it. Lightning, snatched from old Jupiter's hands by Franklin, becomes an instrument of progress. We employ it to transmit our thoughts, to reproduce our works of art, to gild our utensils, and we shall soon make it perform a thousand other services. Before the lapse of half a century we shall see electricity rendered more and more docile, furnishing us with movement, light, and heat, at pleasure.

Will you now study with me how human labor, incessantly multiplied, infinitely increases the usefulness of all our things?

An invisible, disregarded iron-mine renders no service to the men who tread upon it.

On the day the geologist, by the travail of his mind, divines this source of useful things beneath our feet, the soil which conceals it gains to some extent an increased value.

When laborious boring has proved the existence of the mineral, expectation is converted into certainty, and the value of the land is farther increased.

The result of employing labor to work the mine is to bring to the surface some tons of reddish stones containing iron. This matter is not really more useful than the pebbles in the neighboring stream; yet it is more valuable, because it is known that things more profitable to man can be extracted from it by labor. The mineral is treated, and the crude metal, which is of greater value, is obtained. The crude metal is refined, and iron is got, which is better. The iron is treated,

and, by cementation, it is converted into steel. The steel is wrought, and a thousand things directly useful to man are produced.

The utility of these last products increases in a direct ratio to the amount of labor which men have expended. An anvil weighing a thousand pounds is less useful than a thousand wrought files; it costs less labor. A thousand pounds' weight of files costs less labor than a thousand pounds' weight of watch-springs; they contain in themselves a smaller sum of utility. You can easily understand that if the anvil made in a day contained as much utility and was of as great value as a ton of watch-springs, which it took several months to make, everybody would prefer to forge anvils, and no one would weary himself in flattening watch-springs.

Neither a decree, nor a decision, nor a political law, has arranged matters in this wise; Nature herself has done it.

It is necessary, indispensable, inevitable, that labor should constantly augment the utility of things, and that men should buy them at the price of greater efforts on learning that they are more useful. Not only is the existence of utility merely relative to man, but it continually varies with our natural or artificial wants.

A stove is useless at Senegal; an ice-making machine is useless at Spitzbergen. In a locksmith's eyes, pincers are objects of first necessity; a duchess has no use for them. On the other hand, a little bonnet, which does not cover her head, is more useful to her than sixty pairs of pincers, for she requires it to drive in her carriage in the park, and she pays for it accordingly. The agreeable and the useful are perpetually confounded in an advanced state of civilization: I have explained why, in showing that our wants increase with our resources.

Time and distance augment or diminish the utility of our goods. A thing in your hand is of more use to you than if it were ten leagues off. At the distance of ten leagues it is more useful than if it were in America. The greater the distance, the greater is the labor required to enjoy it; you must either pay the cost of carriage or go for it yourself. This fatigue and this outlay are equivalent to the labor that must be expended, for instance, in order to convert iron into steel. A thousand francs in Paris are worth more to a Parisian than a thousand francs in Brussels; a thousand francs in Brussels are worth more than if they were in New York. In like manner a thousand francs which are given you to-day are evidently of greater use than a thousand francs which will be given to you ten years hence. A thousand francs obtainable in ten years are more useful and are worth more than a thousand francs of which the possession is postponed for fifty years. The return may indeed be safe and certainly guaranteed; the question is utility as regards yourself, and you are not sure of living long enough to enjoy a benefit so long deferred.

The utility clearest to all eyes is that residing in material things.

Man understands without any effort that a bird in the hand is worth two in the bush, and that it is still more useful when leaving the spit. It is needless to tell you that first the sportsman and then the cook has added a surplus value to the bird. If I put before you a ton of pig-iron, worth fifty francs, and then a ton of fine needles, worth ninety thousand, you will instantly see the enormous supplement of utility which the work of men has added to the metal.

But there are other benefits of which the utility is not as directly visible to our eyes, though it be at least as great. An impalpable, invisible, imponderable idea is often more useful than a mountain of benefits clear to the naked eye. Man is a thinking body; his hands have done much to render the earth habitable, but his brain has done a hundred times more.

Suppose that a great manufacturer had converted a thousand million pounds of iron into steel. Would he have performed as much usefulness in his life as the discoverer of cementation, as he who has put it within the reach of all men to convert iron into steel? He who should transport a mountain ten miles would produce less utility than the discoverer of the lever. For, by teaching us a simple law of mechanics we have been put in a position to transport a hundred mountains, if we please, with less outlay and effort. An economy is thus rendered possible which will profit all men who have been and may be born.

If Pascal had said to the men of his day, "I am rich, I possess a hundred miles of pasturage around Montevideo, and a thousand vessels on the Atlantic; I have caused half a million of horses to be transported hither, which I present to you, and which will work for you till their deaths," Pascal would have been less useful to the human race than on the day when, in his study, he invented the wheel-barrow.

Studious men, by a series of discoveries, superinduced the one upon the other, have given to us all the machines which abridge and facilitate labor. England alone possesses a hundred millions of horse-power which work for the profit of thirty millions of men.

The history of civilization may be summarized in nine words: the more one knows, the more one can perform.

In proportion as science and reasoning simplify production, the quantity of benefits produced tends to increase without augmentation of expense; work done helps the work to be done. The tools of the human race are nothing else than a collection of ideas. All levers are worn out in the long-run, and all wheel-barrows also; steam-engines are not everlasting, but the idea remains, and enables us indefinitely to replace the material which perishes. It follows from this that the first of useful things for man, is man himself.

You are of the greater use to yourself the more you are instructed, rendered better, and, so to speak, more perfect. The development of your personal faculties also enables you to be more useful to others, and to obtain from them greater services through reciprocity.

CHARLES ROBERT DARWIN.

MR. CHARLES R. DARWIN, the most eminent philosophic naturalist of the age, is now sixty-four years of age, having been born in Shrewsbury, England, in 1809. He is descended from distinguished ancestors on both sides. His father was Dr. Robert Waring Darwin, a Fellow of the Royal Society, and his paternal grandfather was Dr. Erasmus Darwin, author of the once-famous books, the "Botanic Garden" and the "Zoonomia." Mr. Darwin's grandfather on the maternal side was the celebrated Josiah Wedgwood, whose name is intimately associated with the progress of the art of pottery in England. Mr. Darwin attended the Shrewsbury School, spent two years in the University of Edinburgh, and took his degree of B. A. at Christ's College, Cambridge, in 1831.

Mr. Darwin inherited from the author of "Zoonomia" that love of natural history and the allied sciences which has been the labor and the pleasure of his life. In the autumn of 1831, Captain Fitz Roy, R. N., having offered to give up part of his own cabin to any naturalist who would accompany H. M. S. Beagle in her surveying voyage and circumnavigation, Mr. Darwin volunteered his services without salary. His scientific acquirements were already so well known that the offer was at once accepted, Mr. Darwin stipulating only that he should have the absolute disposal of all his collections. The Beagle sailed from England, December 27, 1831, and returned on the 27th October, 1836.

In 1839, Mr. Darwin published a volume as a part of Captain Fitz Roy's general work, descriptive of this voyage. The interest excited by this, one of the most graphic, and at the same time most philosophic book of travels that was ever published, led to its reproduction in a modified form, in 1845, under the title of "Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H. M. S. Beagle round the World." This Journal shows Mr. Darwin to have been a singularly close observer of every phenomenon in natural history, and of every variety of condition, physical and mental, of the people whom they visited during this remarkable voyage, and exhibits the possession of perceptive powers of the highest order. No single phenomenon is described by Mr. Darwin until after it has been most cautiously examined, and the reader of the Journal is soon impressed with the persuasion that the facts narrated are placed beyond a doubt, and that his reasonings on those facts are ever guided by a system of most severe inductive philosophy. This is most especially exemplified in Mr. Darwin's reasonings on the origin of the coral-reefs of the Pacific.

In the beginning of 1839 Mr. Darwin married his cousin, Emma Wedgwood, and shortly after took up his residence at Down, near

Farnborough, in Kent. For twenty-six years, in the retirement of his home, Mr. Darwin has devoted himself to the care of a large family, and the quiet and close investigation of the works of Nature. His first labors, after this date, were editing the "Zoology of the Voyage of the Beagle," giving an account of the habits and ranges of the various animals therein described. In aid of the publication of this and other works bearing on the same subject, the Lords of the Treasury granted £1,000. In 1842, Mr. Darwin published his work on "The Structure and Distribution of Coral Reefs;" in 1845, "Geological Observations on Volcanic Islands;" and in 1846, "Geological Observations on South America."

Continuing, without rest, his researches, we find the results of his unwearying industry in two volumes published in 1851 and 1854, "On Pedunculated and Sessile Cirripedes," and, in two other volumes, on the fossil species of the same class.

Toward the close of 1859, Mr. Darwin published his "Origin of Species by means of Natural Selection." Of this work four English editions have appeared, and nine foreign editions, in French, German, Dutch, Italian, and Russian. Its popularity is shown by the fact that more than one hundred reviews, pamphlets, and separate books, have been published upon it, while the earnestness with which the question is still discussed shows that these will probably be doubled in a short time.

In 1834, Mr. Darwin was elected a Fellow of the Royal Society. In 1853, the Royal Society awarded to him the royal medal, and in 1859 the Wollaston medal was given to him by the Geological Society. In 1862, he published a book full of curious research, "On the Various Contrivances by which Orchids are fertilized." Of separate papers, published by this naturalist, we find the following among the more important: "On the Connection of Certain Volcanic Phenomena in South America;" "On the Distribution of Erratic Bowlders in South America;" "On the Formation of Mould by the Earthworm;" and "On the Geology of the Falkland Islands"—all published in the Transactions of the Geological Society. In the *Journal of the Linnean Society*, three papers have appeared from the pen of Mr. Darwin, "On the Dimorphous and Trimorphous States of Primula," and one paper "On the Movements and Habits of Climbing Plants." This last one has since been published as a separate work. In 1864, the Royal Society awarded to Mr. Darwin the Copley medal, and he has been elected a member of various foreign scientific bodies.

The latest works of this indefatigable naturalist are, "The Variation of Animals under Domestication," in two volumes; the "Descent of Man," in two volumes; and a book "On the Expression of the Emotions in Man and Animals," just published, and some account of which is given in the present number of THE POPULAR SCIENCE MONTHLY.

EDITOR'S TABLE.

TYNDALL'S LECTURES IN NEW YORK.

PROF. TYNDALL'S course of lectures in New York has met with a success that is commensurate with the reputation of the lecturer, and the interest of the subject which he selected for popular elucidation. One of the largest halls in the city has been densely crowded throughout the course of six lectures by the most cultivated and intelligent people of New York and the adjacent towns, and he has been listened to with close and absorbing attention throughout. The first lecture tests a man's reputation, and its degree of success is a measure of the desire to see as well as to hear him. As a result, the first performance often dissipates a reputation. The second lecture tests character and capacity, and an extended course applies the test still more rigorously. Had Prof. Tyndall given but a single lecture, however large may have been his audience, it might have been considered as gathered by curiosity; but when a vast auditorium, like that of the Cooper Institute, is packed to the last by the ablest men in all the professions—science, law, medicine, divinity, and education—with many of our strongest and shrewdest men of business, and a large proportion of our most cultivated ladies, the verdict is unequivocal and assured, and the highest compliment possible is paid to the genius and power of the teacher. No such assemblages as have greeted Prof. Tyndall, and followed him with sustained enthusiasm through his course, have ever before been gathered in New York.

But one interpretation can be given to this success, and that is the growing interest in matters of science, and the increasing appreciation of ability in its expounders. If it be said that the auditors were in search of mere pleasurable excitement, it comes to the same thing, for the pleasurable excitement is derived from a prolonged scientific demonstration. Something was due to the attractiveness of the experiments, and much to the felicity of the professor's manner, but there were abundant and gratifying indications of an earnest desire to comprehend the argument, and get a thorough understanding of the phenomena presented. The strength of this feeling has been put to a significant test in the present case. Just before sailing, Prof. Tyndall had exposed himself to the reprobation of a large class of the community by consenting to introduce to the public Dr. Thompson's paper proposing the so-called prayer-gauge. He thus became an object of bitter attack from religious quarters, and so considerable was the feeling aroused that it was said by many the step he had taken would cost him his American audiences. But the strength of public prejudice was over-estimated, and the progress of liberal feeling forgotten. Twenty-five years ago it would have been different; but such has been the conquest of prejudice, and the enlargement of ideas, that Prof. Tyndall's lecture-rooms, in all the cities where he has spoken, have been filled to overflowing with those who are prepared to accept science on its own merits, without mixing up with it questions of theology.

Another circumstance deserves mention in relation to the success of Prof. Tyndall's lectures in New York. His audience came together upon the bare announcement that he would give them a course of lectures. There were none of the usual trumpetings of managers—puffs, placards, show-bills, portraits in the windows, staring sensa-

tional advertisements, and the customary arts and tricks by which notoriety is manufactured and "success" secured. It is to the credit of New York intelligence, and evinces a growing appreciation of the intrinsic claims of science, that the customary clap-trap of agents, whose maxim is, "The public must have a certain amount of humbug, you know," was entirely dispensed with in the present instance.

Prof. Tyndall's course of lectures was any thing but child's-play for his audience. Boston, indeed, has complained that they were *elementary*, if not *rudimentary;* but Boston is in many things exceptional—there has been no such complaint in other cities. In New York the prevailing criticism has been rather of an opposite kind—not, perhaps, that the lecturer's presentations had been too abstruse for ordinary intelligent apprehension, but that they have been too incomplete to be satisfactory. The phenomena shown have been out of proportion with their explanations, a defect which could only be remedied by giving thirty-six lectures in the place of six. But this was impossible, as Prof. Tyndall's time to tarry with us was short. The method that he has followed, we think, has been very skilfully adapted to the circumstances. There has been a great amount of general reading in books and magazines, and of study in our schools and colleges, upon the subjects he has selected, but the ideas acquired have been vague and unsatisfactory, from lack of observing the actual phenomena that have been read about. The lecturer assumed this state of mind in his hearers, and that the literature of the subject is everywhere accessible for further reference, and he accordingly constructed his course so as to bring under direct observation a wide range of the actual phenomena he had chosen to deal with. These were presented in their beauty and variety, with consummate skill and impressiveness, and as much of elucidation as time allowed. The ideas of many upon the subject of Light, the theory of its nature, and its various complex affections, were clarified and rendered more precise, while many others for the first time witnessed a series of marvellous effects, which gave them a new conception of the exquisite and wonderful play of natural forces, and which will incite them to further study and prepare them for it.

The triumph of Prof. Tyndall, so far from being his first lecture with all its advantages of novelty, was really his last lecture, and what is more, the concluding part of it, which was without experiments. He closed his course by an estimate of the work, and a statement of the claims of original investigators, and this was listened to by his vast audience with a close and almost breathless attention, which attested both the intellectual quality of the assemblage and their interest in the highest scientific objects and themes.

MRS. SOMERVILLE.

To the question "Who is the most intellectual woman that has yet appeared?" a variety of answers will probably be returned; but to the question "Who is the most scientific woman that has yet appeared?" but one answer will be given; it is—"Mary Somerville." Not only was she a woman of eminent capacity, but, what is very remarkable, her mental vigor was prolonged to a period surpassing by many years the allotted life of man. The first work that made her name known to the world was in 1826, and her last book, an able treatise in two volumes, was published forty-three years later, in 1869, and that long interval was fruitful in works of ability in different departments of science.

Mrs. Somerville died at Naples November 29th, within rather less than a month of the ninety-second anniversary

of her birth. Her maiden name was Mary Fairfax; she was of Scotch ancestry and an admiral's daughter. She was twice married, first to Captain Greig, of the Russian Navy, an officer of scientific accomplishments, and to whom she is said to have owed the mathematical and physical culture which subsequently made her name illustrious as the wife of Dr. William Somerville. She became first known by a paper in the Philosophical Transactions, printed in 1826, describing her experiments on the magnetizing power of the more refrangible solar rays. "In her experiments, sewing-needles were rendered magnetic by exposure for two hours to the violet ray, and the magnetic virtue was communicated in still shorter time when the violet rays were concentrated by means of a lens. The indigo rays were found to possess a magnetizing power almost to the same extent as the violet; and it was observed, though in a less degree, in the blue and green rays. It is wanting in the yellow, orange, and red. Needles were likewise rendered magnetic by the sun's rays transmitted through green and blue glass." Such is the statement made by Dr. Turner in his old chemistry, but he adds that "the accuracy of the experiments had been doubted, and that the result must therefore be regarded as one of the disputed points in science." Dr. J. W. Draper went over the subject in 1835, with the sunlight of Virginia, and, although adopting far more delicate methods than Mrs. Somerville, failed to produce the alleged effects.

In 1831 Mrs. Somerville published "The Mechanism of the Heavens," an abridgment and attempted popularization of Laplace's "Mécanique Céleste," which she was induced to undertake by Lord Brougham. The "Connection of the Physical Sciences," perhaps her most valuable work, was issued in 1834, and her "Physical Geography" in 1838. Her last work, on "Molecular and Microscopical Science," published when she was near ninety years of age, is beyond doubt the most remarkable exploit of her life. It is a survey of what has recently been done in the field of Molecular Physics, describes the brilliant discoveries in dialysis and atmolysis, the crystalline and colloid states of matter, spectrum analysis in its celestial applications, the microscopical structure of the vegetable world, and the physics of organization, and all in a constantly clear and often an attractive style. Mrs. Somerville was the recipient of many honors on account of her scientific labors. She received a pension from the Government, was made an honorary fellow of the Royal Astronomical Society, at the same time with Miss Caroline Herschel, received a gold medal from the Royal Geographical Society, and had her bust placed in the library of the Royal Society. She maintained her interest in the movements of the scientific world, was supplied with the latest works in various branches of knowledge, and kept up her correspondence with many of the leading mathematicians and physicists, to within a few weeks of her death. It has to be added that Mrs. Somerville did not neglect the lighter accomplishments and tastes of her youth, but continued her painting, and music, and even her lace-work and other feminine trifles.

If it be asked how she contrived to do these things which are such consumers of time, while also making such extensive scientific acquisitions, the reply is, first, that she was a woman of great capacity and great industry; and, second, that her scientific work was by no means of that highest or creative kind which is produced only by genius and requires the concentration of a life within a narrow sphere of effort. We prefer, however, to abstain from estimating Mrs. Somerville's intellectual character, but will quote the opinions expressed upon this subject by her own countrymen. The *Saturday Review* says:

"A final lesson of importance is forced upon us by the retrospect of so exceptional a career. We may hear it asked how, in the face of powers of intellect and capacity for brain-work such as these, it can be pretended that the minds of women are essentially inferior to those of men. There are, it may be, those among us who would see in this highly-endowed and eloquent expositor of Nature a female Humboldt or Laplace. Far be it from us to speak disparagingly in a case in which the estimate of undoubted merit is enhanced by the sense of recent loss. Still in the balance of truth we must not allow affectionate regard to prevail over judicial candor, or gallantry outweigh critical and sober sense. No one would have been more prompt than Mrs. Somerville herself to disown any idea of intellectual rivalry between the sexes. It was in no sense as a rival to the great discoverers in science, or even as the author or setter-forth of truths novel and original, but simply as the interpreter and expounder in a popular form of what the masters of scientific truth, each in his own province of research, had brought to light, that she set herself her distinctive task. What the laureate has said of the passions of mankind and womankind applies, as experience shows, no less truly to their respective intellects. It is not invidious, still less discourteous, in us to say that the one is to the other as moonlight is to sunlight. Receptive, bright, and keen, the mind of woman may give back or diffuse the rays of knowledge for the source or emanation of which a stronger and more originative power is necessary. The knowledge of mathematics displayed in the 'Mechanism of the Heavens' took the world by surprise because it was that of a woman. Women have made themselves names before now in exact science, even among its higher branches. Maria Agnesi, we cannot forget, was Professor of Mathematics at Bologna in the last century, and Sophie Germain, whose works in pure and applied mathematics won her the Academy's medal, excited the esteem and wonder of the leading *savants* of France. But the high places of science, the seats of supreme authority and prime origination, exalted and few, are for a class apart."

A writer in the London *Athenæum* remarks:

"It is not too much to say that the chief value of her version of Laplace's masterpiece resides in the fact that the work exhibits an unmistakable proof of her mathematical power. It is difficult to conceive that any student of science could profit by the study of the work. As a first introduction to celestial mechanism it fails, because all the portions which present any difficulty are left uninterpreted: while to the more advanced student the work is useless, because such explanations as are given relate to the simpler parts of the subject. But it is impossible to rise from the perusal of the work without feeling that Mrs. Somerville herself had fully grasped the meaning of the great mathematician, and had followed his reasoning even where it had led him to the highest range of the modern methods of analysis. At the same time, it must be admitted that nothing in this work suggests the idea that Mrs. Somerville possessed in any considerable degree the inventive power which is the distinguishing attribute of great mathematicians. When we consider her work in other branches of science, a similar quality of mind is discernible. We cannot recall any experimental researches of hers which were characterized by originality, or any passage in her writings suggesting new ideas on the scientific questions which she discussed. She possessed but little power of generalization; and we believe it is this peculiarity of mind rather than any want of distinctness in expression which has led to the defect characterizing her attempts to popularize science. It is not commonly recognized, but is nevertheless the fact, that the perfect concatenation of ideas throughout a chapter or section of a science treatise is altogether more important than distinctness of expression in individual sentences, desirable though the latter quality necessarily is. But in Mrs. Somerville's science writings there is a want of sequence; and this is seen not merely in her general treatment of her subjects, but even in paragraphs and sentences. We may take the following sentence from her latest work, 'Molecular and Microscopic Science,' as a noteworthy instance. Endeavoring to prove the eternity of the soul, she says: 'To suppose that the vital spark is evanescent while there is every reason to believe that the atoms of matter are imperishable, is admitting the superiority of mind over matter; an assumption altogether at variance with the result of geological sequence; for Sir Charles Lyell observes that sensation, instinct and sensation of the higher mammalia bordering on reason, and lastly, the improvable reason of man himself, presents us with a picture of the ever-increasing dominion of mind over matter.' The readers whom the popu-

larizer of science addresses are more apt to be perplexed by a *non sequitur* such as this than by mere verbal peculiarities."

LITERARY NOTICES.

TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS (1870–'72). Atwood & Culver: Madison, Wis.

THE State of Wisconsin is but just of age, having emerged from its Territorial infancy and entered upon its sovereignty only twenty-two years ago. This is but a short period in the lifetime of an independent political community, yet much has been done within that period to give the State an impulse in the direction of civilized development. Taking journalism as a standard, the number of newspapers and periodicals printed in Wisconsin, in 1870, was no less than 174—of which 6 were monthly, 1 semi-monthly, 14 daily and weekly, and 153 weekly. In 1870, was organized, at Madison, the capital, the Wisconsin Academy of Sciences, Arts, and Letters, devoted to the material, intellectual, and social advancement of the State. This association numbers at present 55 annual members, 29 corresponding members, and 12 life-members. The first volume of the proceedings, now before us, is a very interesting document, the first part of which is a report to the Legislature by Dr. J. W. Hoyt, President of the Academy, which gives an account of its establishment, and a valuable inventory of the contributions to philosophy, political science, social science, natural science, and the useful and the fine arts, by distinguished citizens of the State, within the last few years. The remainder of the volume of proceedings is filled with a series of original papers in the several departments, many of which are able and instructive. The plan of the institution is comprehensive, and if it is sustained, as it ought to be, it cannot fail to be of great service in promoting the higher prosperity of the State.

PHYSICS AND POLITICS; or, Thoughts on the Application of the Principles of "Natural Selection" and "Inheritance" to Political Society. By WALTER BAGEHOT,[1] Esq., author of "The English Constitution." D. Appleton & Co.

THE second volume of the "International Scientific Series" is now issued, and it is but just to say that it ably sustains the character of the enterprise. It was no easy task to follow Prof. Tyndall, the clearest of our scientific thinkers, and most elegant and eloquent of our scientific writers; and, had a similar subject been chosen, we could have hardly expected a monograph so finished as the "Forms of Water." But Mr. Bagehot's theme is widely dissimilar from that of Prof. Tyndall, and, although treating of a subject at the opposite pole of science (if we may so speak), is not less attractive, and is presented with great literary skill, keenness of analysis, and originality of view. The author is unknown in this country, except through various essays in the *Economist*, of which he is the editor, and in the periodicals; but he takes a high rank among the thinkers of England. His book on "The English Constitution," which will shortly be republished here, is unquestionably the ablest work on the philosophy of modern politics that has appeared in a long time, and at once placed its author in the front rank of writers upon the science of government.

The volume now issued is not only from the latest point of view, and stamped with all the freshness of recent inquiry, but it is a pioneer discussion which clears a path of investigation that is certain to be followed up in the future with the most marked and valuable results.

If any one were asked to name that field of thought which is at present most chaotic and discordant, where there are the fewest settled principles, and the most arbitrary assumptions, in which everybody can dabble with equal claims to attention, and where scientific knowledge is utterly scouted as of no manner of use or application—it would of course be that of politics. In almost every other field where the human mind requires to be used, a certain amount of knowledge is regarded as indispensable; but in politics the charlatan and the ignoramus put forth equal claims with the trained and painstaking thinker. This state of things cannot last. The advance of knowledge is irresistible, and it will as certainly produce a revolution in politics as it has already produced revolutions in so many other departments of thought. This pestifer-

[1] Pronounced Bá-jote.

ous swamp of humbugs and impostures is bound to be drained and reclaimed to the higher uses of civilization.

"Physics and Politics" has been written to show that the noble field of political thought and activity is not necessarily the chaos it is generally supposed, but that it involves great natural laws, which it is the destiny of science to trace out and formulate, just as it has done with other branches of knowledge which have been made scientific by modern inquiry. In what does the progress of political communities consist, and how has it arisen? What were the first conditions and steps of social advancement? What are the uses of slavery, war, and other barbarities in the early tutelage of races? And when the rude stages of barbarism and violence are passed, what are the recent agencies which take up the work of amelioration and carry it up to still better and finer results? These are the questions which Mr. Bagehot answers in his successive disquisitions on "The Preliminary Age," "The Use of Conflict," "Nation-Making," "The Age of Discussion," and "Verifiable Progress Politically considered." In treating these questions, the author brings out the action of those laws of Nature and of human nature that precede the age of legislation, and are a thousand times more potent than the edicts of kings or the enactments of congregated law-makers.

To the cultivated reader who enjoys literary excellence, fine analysis, fresh and striking views, with many passages of picturesque eloquence, and all vivifying and illuminating a current of close and vigorous reasoning, this little treatise on "Physics and Politics" will prove a rare treat. We had marked several passages for quotation, but lack of space prevents their insertion.

DEDUCTIVE AND INDUCTIVE TRAINING. An Address before the Chemical Society of the Lehigh University, by B. SILLIMAN, M. A., M. D. Printed by the Society.

IN this discourse, which was given at the first annual celebration of a young chemical society, Prof. Silliman regards the problem of higher education from the modern and American point of view—not as a radical innovator, but as a friend of rational progress and judicious reform. He says:

"Public opinion, however, has made itself felt by the outward pressure it has exerted, and the demand, which has grown up for men better trained in general science, and in its several departments, has brought about a change, visible on every hand, alike in the modification of the studies, as in the development of new departments with separate Faculties devoted to science-training; as also occasionally in the establishment of new institutions, on entirely independent foundations, in some of which only special subjects are taught, while in others the experiment is on trial of a curriculum, in which the modern languages, either wholly, or in part, replace the ancient, and where the student is trained during three or four years by a course of studies in which the inductive sciences have a prominent part."

Prof. Silliman admits the former excess of deductive training in our colleges, and recognizes the necessity of so modifying the curriculum as to introduce a larger amount of inductive science to correct the evil, and afford a sounder and more symmetrical culture. On this point he observes:

"The defect of an education based on the study of the deductive methods of geometry, the pure mathematics, jurisprudence, and ancient literature, will now be readily understood. Intuitive principles, those which underlie geometrical and mathematical studies, or those principles obtained by common consent, and of human authority, which are the foundations of jurisprudence; or again, the study of the historical, poetical, and literary precedents, images, and ideas of ancient writers, and their rendering into English, which is the staple of the ancient classics, leaves completely undeveloped the entire body and soul of ideas connected with the experimental and demonstrative sciences, which have to do with natural phenomena, and the entities of natural history in the broadest sense. In other words, no room is left for the study of the *inductive methods*, the logic of science, by the aid of which we, in this nineteenth century, find ourselves so immeasurably in advance of all former times, in our ability to comprehend and control the powers of Nature, and adapt them not only to the service of our human wants, but, what is more, to the interpre-

tation of cosmical laws, and the hidden mysteries of molecular physics."

The professor protests alike against the narrowness of the traditional culture on one side, and the newer policy of our scientific and technological schools.

"In urging the plea for science-education, let it be remembered that we speak of education in its broad and well-rounded sense, by which *all* the powers of the human mind are to be developed into a symmetry which shall dwarf none of them. We claim, with great reason, the existing system does not do this, and is incapable of doing it, owing to the overshadowing importance attached to the ancient classics, absorbing so much of the time given to education that only a fragment can be grudgingly given to the study of the inductive sciences. But no institution, as we have before remarked, which is confined to the training of men for special professional work can be regarded, in the broader sense of that term, as an educational institution, however ably it may discharge the more limited work which is assigned to it. The want of ethical and literary training and general culture at West Point has always been recognized as a deficiency, in a system in many other respects unsurpassed, and the same is true of all institutions similarly organized."

RECENT DISCUSSIONS IN SCIENCE, PHILOSOPHY AND MORALS. By HERBERT SPENCER. New and enlarged edition. D. Appleton & Co., 350 pages.

THIS volume completes the first collection yet made of Mr. Spencer's miscellaneous essays. It contains thirteen papers, most of which have not before appeared in this country, and there are six more articles added to the present edition. The volume is especially valuable, as containing Mr. Spencer's complete discussion of the system of Comte, the classification of the sciences, the genesis of knowledge, and the work of discovery of general laws. The other articles are "Specialized Administration"—a reply to some views of Prof. Huxley in his articles on "Administrative Nihilism," "What is Electricity?" "The Constitution of the Sun," "The Collective Wisdom," "Political Fetichism," and "Miss Martineau on Evolution." As remarked in the preface to this work, "these several discussions have been drawn from Mr. Spencer at various times to correct misapprehensions and misrepresentations that have been made regarding the doctrines of his system of philosophy. Some of them form valuable extensions of these doctrines, and all will be useful in promoting their right interpretation."

MISCELLANY.

Volcanic Energy.—Mr. Mallet, in a paper read before the British Royal Society, claims that volcanic heat results simply from the secular cooling of a terraqueous globe subject to gravitation. He rejects the chemical theory, on the ground that facts show the chemical energies of the globe almost wholly exhausted prior to the consolidation of its surface. The mechanical theory he also rejects, it being, according to him, proved untenable by the known thickness of the earth's crust. He then points out various relations and points of connection between volcanic phenomena, seismic phenomena, and the lines of mountain elevation, attributing all three to one set of cosmical forces, which decay with time. As our globe contracted, there occurred deformations of the spheroid, forming the ocean-basins; next came the foldings-over and elevations of the thickened crust into mountains; and, lastly, we have volcanic action. The author accepts C. Prevost's theory of mountain elevation, viz., tangential pressures propagated through a solid crust, and produced by the relative rate of contraction of the nucleus and of the crust. As the nucleus shrinks, the crust is partially unsupported. During the very rapid cooling from a high temperature, with a thin crust, we should have mountain elevation as a result; but the same causes give rise, in the present state of things, to volcanic heat. As the solid crust sinks after the nucleus, its crushing together is transformed into heat sufficient to fuse the rock. The access of water then determines volcanic action. Mallet made two series of experiments to test his theory. He first crushed sixteen species of rocks, representing the whole series of formations from oolites to the hardest crystalline rocks. The second series of experiments, conducted on a very large scale, was to ascertain the coefficients of total contraction, between fusion

and solidification at existing mean atmospheric temperature, of basic and acid slags, analogous to melted rocks. Mallet thus finds that less than one-fourth of the heat annually lost by our globe is sufficient to account for its total annual vulcanicity. He then shows the accordance of his views with sundry facts of vulcanology and seismology. Finally, he accounts, on his theory, for the elevations on our moon's surface, and the evidence there of former volcanic energy, on a grander scale than on our planet.

The Vibrations produced by Various Explosives.—It is known that the instantaneous combustion of an explosive body is brought about by vibrations, independently of the agency of heat. An interesting inquiry here arises, whether these vibrations are identical for all explosives; and whether we can determine in advance the action of one explosive upon another. Two French *savants*, MM. Champion and Pellet, have investigated this subject, and the following is an account of their experiments: First, they set up an apparatus with eight gas-burners, to give "singing" flames, answering to the eight notes of the gamut. For the first experiment an anvil was placed at a distance of sixteen feet from this apparatus, and on it they placed in succession 0.03 grammes of iodide of nitrogen and fulminate of mercury, both enclosed in sacks of gold-beater's skin. The iodide, on being exploded, had no effect on the flames, while the fulminate caused the following flames to play: *la*, *do*, *mi*, *fa*, and *sol*. The conclusion is, that the vibrations produced by the two agents differ mutually, and further, that the vibrations caused by the fulminate act on some notes, passing over the others. In the second experiment the flame-apparatus and the anvil were placed twelve feet apart. It was now found that the iodide acted on the higher notes, whereas the fulminate affected the entire scale. But, if now we make each charge two decigrammes, and bring the anvil very close to the apparatus, the whole gamut will respond to both explosions. The third experiment was a repetition of the foregoing two, with this exception, that nitro-glycerine was substituted for iodide of nitrogen. The result did not show any difference between these two agents in their action on the flames; and yet it is known that there *is* a difference between their respective vibrations; for the fulminate will explode compressed gun-cotton, but nitro-glycerine will not, under identical conditions. No doubt, if a more perfect flame-apparatus, with a series of low notes, had been employed, a difference would have been manifested in the course of the experiment.

Economy of Fuel.—A self-feeding furnace is now in use in several English manufacturing towns, which is said to effect a great economy in the consumption of coal, besides possessing the additional advantages of burning all the refuse and completely consuming the smoke. A small and uniform amount of fuel, just enough to replace that consumed, is being constantly added to the fire, which is supplied with exactly as much air as is required to carry on the combustion in the most economical and effective manner. The apparatus is known as Vicar's Furnace, and is readily fitted to any kind of boiler, and to reverberatory furnaces of all descriptions.

Ammonia in Snow-water.—Dr. Vogel has an article on ammonia in snow-water in the *Sitzungsberichte der mathematico-physikalischen Classe*, of the Munich Academy of Sciences. The method employed by him is that of Schlösing, for estimating the amount of ammonia in arable soil. The results obtained were as follows, one litre (2.113 pints) being the unit: Freshly fallen snow, caught in a porcelain basin, at zero, gave 0.003 grammes; at −3° gave 0.002; at from −9° to −15° gave no ammonia. Water from snow which had stood 24 hours on a piece of manured garden-ground, contained 0.012 grammes; from snow which had stood on a meadow for 24 hours, 0.009 grammes; from a zinc roof, 0.004 grammes. Dr. Vogel observes that the quantity of ammonia in snow depends on a variety of conditions, and that, since snow, owing to its porosity, absorbs ammonia (and the same is true of snow-water), it is necessary to melt it in closed vessels. The amount of ammonia in snow is also dependent on the temperature at which it falls. At a rather

low temperature (—15°), the author could not detect ammonia in snow.

Cultivation by Steam.—At an agricultural meeting, recently held in Scotland, some interesting statements were made respecting the origin, progress, and results of cultivation by steam in Europe. In 1855, a Mr. John Fowler, of Essex County, England, started his first steam-plough. Now, in Great Britain, there are single establishments for manufacturing steam-ploughs, so extensive that they furnish constant employment for not less than 1,200 men. In England, between 400 and 500 sets of steam-ploughs, held, some by companies and others by individual owners, are worked for hire, and are found to be a profitable investment. A tract of 500 acres, near London, so unproductive that it could not be rented for $3 per acre, was bought by an enterprising farmer, who removed the fences, under-drained, and, with a steam-plough, put the whole into grain-crops. Last year, after allowing 10 per cent. on the money invested in the land, his clear profits were $18,000. The soil he thus improved by deep steam-ploughing is a stiff clay that could not be profitably worked by horse-power. Another tract of 5,000 acres, that had been regarded as worthless, was bought by a farmer who ploughed it with steam-power to the depth of 3 feet, and was rewarded by crops of astonishing thrift. In Scotland, cultivation by steam is becoming general, and producing results equally marvellous. Joint-stock companies are investing in land and steam-machinery, and securing large dividends, while individual farmers have invested from $6,000 to $10,000 in steam-machinery with very profitable results. In Germany also steam-power is working a revolution in agriculture.

It was also stated that the Pasha of Egypt now employs on his extensive domain 400 steam-ploughs, and is building "on his farm" 400 miles of railway, and, for transporting and manufacturing the raw material produced, has ordered thirty locomotive-engines and $3,000,000 worth of sugar-machinery.

Perhaps the most successful cultivator by steam in America is Mr. E. Lawrence, of Magnolia Plantation, parish of Plaquemine, Louisiana. In a letter to the Agricultural Department, he speaks of the results of his trial of the steam-plough as follows:

"Two hundred and twenty acres of my cane-crop, 140 acres of which were plant-canes, and 80 acres first-year rattoons, were, I believe, as thoroughly ploughed and cultivated by steam as could be desired. The 80 acres of first-year rattoons, grown from the stubbles of the *steam-ploughed cane* planted in a similar manner last year, were barred off and well dug in the month of March, then subsoiled and cultivated by steam precisely as the plant-canes. The yield was over 2,500 pounds of sugar to the acre."

Mr. Lawrence closes his letter with the prophecy:

"Necessity will soon compel us to take a 'new departure.' The constant increase of immigration and population in the grain-growing States of our country will soon demand a better cultivation and increased production. In England, steam-ploughing has increased the yield of wheat from 16 bushels to 28 bushels to the acre.

"I do not believe the agricultural interest of our country can much longer turn a deaf ear to this last and greatest achievement of steam—its successful application to the cultivation of the soil. It has broken the yoke and lifted the burden which, for ages, held both man and beast in bondage, ameliorating their condition by making that which was most onerous easy and attractive; it has elevated labor, and dignified the plough."

Ozone by a New Process.—An apparatus for manufacturing ozone, patented by Dr. Loew, is mentioned in the *Journal of the Franklin Institute.* Some time since Dr. Loew observed that cold air blown through a flame is in part converted into ozone, and his apparatus is constructed with a view to turn this observation to practical account. It consists of a number of Bunsen burners, set up in a row, with an equal number of horizontal tubes at some distance above the burners. The cold air is blown through the tubes against the flames, and is then collected, in the shape of ozone, by a number of funnels placed on the opposite side of the flames. The ozone is to some extent contaminated by acetylen and nitrous acid.

The English Sparrow.—In a paper lately read before the Long Island Historical Society, by Mr. E. Lewis, Jr., and since published in the *Brooklyn Union*, we find the following interesting particulars concerning the importation into this country of the English sparrow, and the valuable service it has since rendered in clearing our city trees of insect-pests. As many are aware, the trees of Brooklyn some years ago were overrun by a species of caterpillar (*Ennomos subsignaria*), which, commencing when the leaves were young and tender, devoured them so rapidly that in a short time the branches were completely bared, making the tree an unsightly object, and greatly injuring its health and growth. The creatures also had the disgusting habit of suspending themselves from the limbs, whence they would drop in great numbers both upon the pavements and passing pedestrians. The maple, horse-chestnut, elm, and willow, were thus attacked, and their destruction, or that of the caterpillars, was the alternative presented to the Brooklyn people. All sorts of expedients were proposed, and among them the introduction of the English sparrow. In spite of the failure of a previous attempt, a second was decided on, and in the fall of 1856 Mr. Thomas Woodcock, of Brooklyn, at the instance of the Brooklyn Institute, brought over from Manchester about a dozen sparrows, which were liberated in the following spring, when they flew away toward Brooklyn Heights. Nothing more was heard of them until the spring of 1858, when two pair were observed among the ivies of Grace Church, where it is probable that one or more nests were built, as during the summer young sparrows were noticed in the vicinity. Since that time their increase has been enormous, and almost solely through their agency the caterpillar nuisance has been completely removed.

According to Mr. Lewis, though feeding largely on seeds, and in cities upon almost every article of human food, the sparrows feed their young chiefly with worms, larvæ, the soft portions of coleoptera, moths, and other tender animal food. "By this means the number of devouring worms has been greatly diminished. The leaf-rolling caterpillar of the sycamore and the currant-bush are known to be taken and devoured by sparrows. The inch-worm, too, is taken when young, as is the Japanese silk-worm, which feeds upon the ailantus-leaf.

"But the sparrows destroy the caterpillar family in a more effectual way than this. The large female moths of the *Samia cynthia*, or Japanese silk-worm, are seized for the eggs which they contain, torn to pieces, and the eggs devoured. So persistent are the sparrows in watching for and catching these moths, that a gentlemen in this city has been unable to raise either worms or moths unless protected from the birds.

"The moths, both male and female, of the inch-worm or tree-caterpillar, are eaten by sparrows. After seizing the moth, they will beat off its head and wings and feed to their young the soft parts of the insect.

"The destruction of the female moths arrests the increase of the caterpillars in a most effective way. But this is not all. We have referred to the sparrows feeding upon the eggs of moths after being deposited upon branches of trees. I have watched them at this frequently during the winter. These eggs are usually deposited in places where they are sheltered by raised or fractured fragments of the old bark, and are covered with a glutinous substance. The sparrow labors until fairly weary in breaking away the old bark and laying bare the eggs, which it removes with some difficulty, but which it nevertheless removes and devours.

"It is thus apparent that the chance for a full crop of caterpillars is small where sparrows are abundant. Indeed, the disgusting tree-caterpillar has disappeared from our city altogether."

The Brooklyn Institute has also attempted the introduction of English song-birds, but as yet with indifferent success. Among those brought over are the skylark, woodlark, goldfinch, robin, and thrush. Some are known to have survived and produced young; but the general impression is that our winters are too severe for them to do well in this climate. "The sparrows," says Mr. Lewis, "seem to be well acclimated, although many have been found dead, after severe frosts and snow. It is evident that the severity of the climate, or some other cause, has somewhat arrested their growth, as persons, who are competent to

judge, say they are a little smaller than in the English towns."

The Uses of Asbestos.—The mineral formation called asbestos—which term denotes rather a peculiar form assumed by sundry minerals than any particular species—is coming to be used very largely in practical mechanics and manufactures. The name *asbestos*, signifying indestructible, was given by the ancients to various amphibolic and augitic minerals, which occur in long, hair-like crystals, placed side by side, forming a fibrous mass. These crystals may easily be taken apart, and, as they are very elastic and pliant, have been used to manufacture a sort of cloth. The Romans used sometimes to envelop the bodies of their dead in a wrapping of this fabric, thus keeping their ashes separate from the ashes of the funeral-pile, for fire does not consume asbestos. We even read of napkins and articles of dress being made of this material—when soiled they were cleansed by being subjected to the action of fire. In ancient times the wicks of the ever-burning lamps in temples and shrines were often of asbestos, and at the present time the Greenlanders make a like use of it. A few years ago a Mr. Audesluys, proprietor of a large asbestos-deposit in the vicinity of Baltimore, commenced the manufacture of a paper containing about 30 per cent. of asbestos. Characters written on such paper, in common ink, are still legible after it has been subjected to the action of fire, and it is likely that advantage will be taken of this property of asbestos to manufacture a paper for important records. The great objection to all the asbestos paper so far made is its want of toughness, its friability. The *Journal of the Society of Arts* makes mention of an asbestos paper covering for roofs, but, as this mineral is not proof against moisture as it is against fire, experience alone could determine its value for that purpose. But, perhaps, the most important service yet rendered by asbestos is the furnishing us with a fire-resisting packing for piston and pump rods, the necks of revolving retorts, etc. Asbestos packing was used for the piston of a locomotive on the Caledonian Railway from July 27 to November 18, 1871, and was then as good as when it was first put in; while the best common packing would have lasted not above two months. It is better to make rings of asbestos, and put them on the piston, than to wind it round. There are very extensive deposits of this important mineral within the limits of the United States, that found on the eastern slope of the Green Mountains and of the Adirondacks being of the best quality for fineness and tensile strength. The fibre of New York and Vermont asbestos varies in length from two to forty inches, and resembles unbleached flax, when found near the surface; but when taken at a greater depth it is pure white, and very strong and flexible. It is found also in considerable quantities in the Tyrol, in Hungary, Corsica, and Wales.

British Scientific Expedition.—The enlightened liberality of the British Government in fitting out the steam-corvette Challenger, 2,306 tons, for a scientific voyage around the globe, receives the heartiest commendation from the English press, and from the whole world of science. The commander of the corvette, Captain Nares, R. N., is a distinguished seaman and explorer, and the second in command, Commander J. P. Maclear, R. N., is scarcely less eminent. We have space only for the names of a few of the scientific men who go out on this cruise. The director is Prof. Wyville Thompson, and he has under him J. J. Wild, of Zurich; J. Y. Buchanan, of Edinburgh, chemist; H. N. Mosely, naturalist; Dr. Von W. Suhm, do.; John Murray, Edinburgh University, do. The vessel has been thoroughly repaired and fitted for her work, with auxiliary screw, two engines of 400 horse-power each, boats, 40 dredges, etc. She carries an abundance of traps, harpoons, scientific apparatus, etc. The route of the vessel will probably be, first, to Gibraltar and the Bay of Biscay; thence to Madeira, St. Thomas, the Bahamas, Bermuda, and the Azores. From the Azores she will sail for Bahia, touching at Fernando Noronha. Thence she crosses to the Cape of Good Hope, from which point her course is southward to the Crozetts and Marion Islands and Kerguelen's Land. Thence her direction will still be southward, as far as the ice will permit, and then the vessel will steer for Sydney, New Zealand, the Camp-

bell and Auckland Groups, Torres Straits, New Guinea, and New Ireland. A cruise among the Pacific Islands will probably take up a twelvemonth, when the expedition, passing between Borneo and Celebes, and visiting Luzon and its neighborhood, will make for Japan, there to remain for a couple of months. Kamtchatka will next be visited, whence a run will be made northward through Behring's Straits; thence through the Aleutian Islands, southward to Vancouver's Island, and so through the deep eastern region of the Pacific by Easter Island, and possibly to the Horn, through the Galapagos, and home. The voyage will take between three and four years, and from it results of the highest importance for science may be expected.

The Venomous Snakes of India.—A new book has been recently published by Dr. Fayrer on the venomous snakes of India, and the treatment of their poisonous bites. In Bengal the people suffer terribly from these reptiles. Dr. Fayrer says: "The frightful scourge of these animals is shown by the fact that the recorded deaths in 1869 were 11,416. But it is more than probable, considering the imperfection of Indian records, that 20,000 was nearer the true mortality." He has given a description of some new species of *Hydrophidæ* or poisonous sea-snakes which infest the Indian seas. These elegant creatures, with small heads and tiny jaws, will bite a man while bathing, inflicting an almost imperceptible wound, unnoticed at the time, but of which he dies in a day or two. About the most poisonous of the Indian reptiles is the cobra de capello, or hooded snake. The elevated skin of the back of the neck presents, when the animal is viewed in front, much the appearance of a hood. It is also sometimes called the spectacle snake, from a singular mark on the back of its neck, closely resembling a pair of old-fashioned spectacles. The cobra is some three or four feet long, of a pale, rusty-brown color above, and bluish or yellowish-white below. Its venom is extremely powerful, the bite sometimes causing death in less than two hours. This venom, though so exceedingly poisonous when introduced into the system, is comparatively harmless when taken into the stomach. It has a sharp taste, but no odor. Usually the cobra is a sluggish creature, and is easily killed. It seldom uses its fangs except for the purpose of obtaining food. One of its most disagreeable habits is an evident liking for the habitations of men, being frequently found near houses, and not rarely in the dwellings themselves.

In regard to cures for the bite of the cobra, Dr. Fayrer's experiments, no less than universal experience, bear testimony to the efficacy of the ligature, if applied promptly and tightly, near the wound, between it and the heart, and followed by excision of the wounded part and the application of the actual cautery. In case a finger or toe is bitten, amputation should immediately be performed at the next joint. Dr. Fayrer's principal snake-man was once bitten by an echis. Immediate excision and cauterization fortunately saved him. When the virus is once in the blood no known agent is capable of neutralizing it.

Some of Dr. Fayrer's results are extremely interesting and of great practical value. He finds that these snakes have the greatest repugnance to carbolic acid, which acts as a powerful and fatal poison to them. The practical advantage of using carbolic acid freely in and about houses in India must therefore be great. The practice of sucking a bite is not so absolutely safe as has been hitherto supposed. The poison may be absorbed through the buccal mucous membrane, or the lining membrane of the stomach, when it will produce its fatal effects.

The most venomous of these snakes seem to possess a perfect immunity from the poison of their own species, and considerable immunity from the poison of other species. Dr. Fayrer says: "In many of the various experiments I have performed, the cobra, daboia, and krait, did not appear to be able to poison themselves or each other. This result was not absolutely invariable, but sufficiently constant to be remarkable." On this point Dr. Fayrer's observations confirm those made by Dr. Russel. Snake-poison acts with most vigor on warm-blooded animals; birds die very quickly. The power of resistance is generally in proportion to the size of the animal, but not invariably so. For instance, a cat will resist the poison as

long as a dog three or four times its size. Cold-blooded animals, fish, non-venomous snakes, and invertebrate animals, all die when bitten. There seems to be a certain difference in the action of the colubrine and viperine snakes. In poisoning by the colubrine snakes, the blood coagulates firmly, but in death by the viperine it remains permanently fluid—at least this was the case in many of Dr. Fayrer's experiments.

A New Fire-Escape.—At the International (London) Exhibition of 1872, Major E. R. Wethered exhibited a fire-escape, consisting of a canvas cradle, with a guard-band to be passed beneath the arms, a strong rope, and a pulley furnished with a clamp, which can be worked by the hand, as the fugitive descends. At an alarm of fire, the sashes of the window are to be thrown into close correspondence at the top. The rope is then thrown around them at one side and hitched with a hook. The lateral pull of the weight will jam the sashes in the frame. The pulley, having five friction rollers, between which the rope runs sinuously, and a clamp worked by lever and handle, is fixed a little above the cradle. The free end of the rope is coiled on a reel, and is thrown out of the window, unwinding as it falls. In addition to the clamp, the descent of the cradle may be governed by the left hand of the fugitive, running along the rope.

Necessity of Carefulness in Old Age.—An old man is like an old wagon; with light loading and careful usage it will last for years; but one heavy load or sudden strain will break it, and ruin it forever. Many people reach the age of fifty, sixty, or even seventy, measurably free from most of the pains and infirmities of age, cheery in heart, and sound in health, ripe in wisdom and experience, with sympathies mellowed by age, and with reasonable prospects and opportunities for continued usefulness in the world for a considerable time. Let such persons be thankful, but let them also be careful. An old constitution is like an old bone—broken with ease, mended with difficulty. A young tree bends to the gale, an old one snaps and falls before the blast. A single hard lift; an hour of heating work; an evening of exposure to rain or damp; a severe chill; an excess of food; the unusual indulgence of any appetite or passion; a sudden fit of anger; an improper dose of medicine—any of these, or other similar things, may cut off a valuable life in an hour, and leave the fair hopes of usefulness and enjoyment but a shapeless wreck.

NOTES.

THE friends of Prof. Huxley will be glad to learn that the latest reports of his health are most encouraging. He broke down last year, and went to Egypt to recuperate, but returned but little better than he left. He seemed to have been very hard hit, and his friends feared that it might be long before he would recover himself. He has lately been elected Lord Rector of Aberdeen University, for three years, which is significant, as showing the way the currents of thought and sympathy are setting.

IT is reported that a cargo of Australian beef, in the fresh state, has been brought to New Orleans without damage, notwithstanding the fact that the temperature of the atmosphere, for a large part of the distance, ranged as high as 90 degrees. The carcasses were packed in ice, also produced in Australia, by a process so economical that it is thought this method of transportation may be made a pecuniary success.

A VERY good liquid glue is got by dissolving glue in nitric ether. It is more tenacious than that made with hot water, and may be rendered almost damp-proof, by introducing a few pieces of caoutchouc, and letting the solution stand a few days, with frequent stirring. As the ether will dissolve only a fixed amount of glue, the mixture cannot be made too thick.

THE *Mechanics' Magazine* notes the casting, at Woolwich, of an enormous steam-hammer, consuming 100 tons of metal. The anvil-block, to serve as a *pièce de résistance* for this enormous engine, after cooling off for three months, was not yet cold enough to be removed.

AN apparatus has been recently devised in Germany for obtaining specimens of water at any desired depth of the ocean. A strong, heavy vessel, entirely closed and empty, has a valve through which water may be admitted, but which is only put in motion by means of powerful electro-magnets connected therewith. These magnets are also connected with a wire which accompanies the rope, by means of which the apparatus is lowered from the ship. When the empty vessel, which is in fact a

plummet, has reached the required depth, an electric current is sent from the battery on shipboard to the coils below; the magnetism thus generated opens the valves, and the vessel is filled and ready to be drawn up.

In his evidence before the Royal Commission on the water-supply of London, Dr. Parkes states that where the population of any town shows a considerable amount of diarrhœa, and also of typhoid fever, it would lead him to regard the water-supply with suspicion; for the health of the population, as regards these diseases of the intestines, seems to be very much influenced by the purity or impurity of the water consumed.

It is proposed to employ tin-foil in place of paper for decorating walls. The foil for this purpose is cut in sheets about 16 feet long and 40 inches wide. After having been painted and dried at a high temperature, the sheets receive the ornamental figures, and are then varnished and again dried. The hanging is done much like paper-hanging, varnish being applied to the wall instead of paste. The foil excludes damp, and can be laid as readily on an irregular as on an even surface, and thus the highest artistic effects can be produced at pleasure.

A writer in *Hardwicke's Science Gossip* tells of a water-wagtail which he saw acting as purveyor to a young cuckoo. The wagtail was seen, again and again, to fly down from a tree, and run along the rail on which the cuckoo was perched, bringing each time to the latter some insect to supply its hunger.

Orange Cultivation in Louisiana.—There is a steady increase, in the orange district of Louisiana, of this species of husbandry. In Plaquemine Parish some 2,000 acres are occupied by orange-groves. Usually, there are one hundred trees to the acre, and a healthy tree will bear from 500 to 2,000 oranges, 1,000 being a fair average field. They bring, on an average, $10 per thousand.

The iron mountains of Missouri, according to Prof. Waterhouse, contain enough ore above the surface, to afford, for 200 years, an annual supply of 1,000,000 tons. Shepherd Mountain is 600 feet high, and its ore contains a large percentage of iron. Pilot Knob rises 1,114 feet above the Mississippi; its base, 581 feet from the summit, is 300 acres, and the upper section of 141 feet is judged to contain 14,000,000 tons of ore. Iron Mountain has an elevation of 228 feet, and an area of 500 acres at its base. The solid contents of the cone are 230,000,000 tons. At the depth of 150 feet, the artesian auger was still penetrating solid ore. The iron from all these mountains is strong, tough, and fibrous.

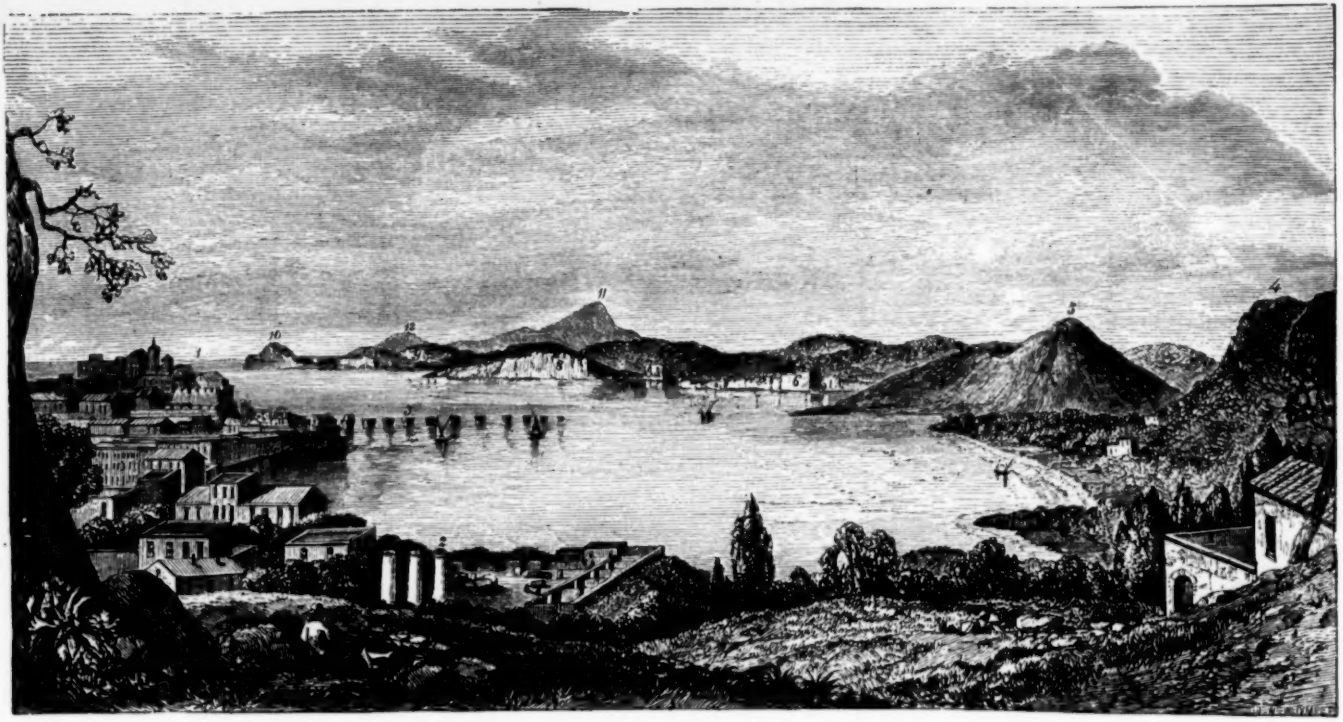
Died, October 28th, aged sixty-five, Dr. Friedrich Welwitsche, the distinguished African botanist. He got his first lesson in his favorite science from a village apothecary, and so an interest was awakened for botanical studies. The "Flora of Tropical Africa" has received from him very important contributions. He acquired distinguished reputation also as an entomologist and zoologist.

In criticising the evidence given by Dr. Letheby before the Royal Commission on the London water-supply, Dr. Hassel, in "Food, Water, and Air," maintains that "it is a fact, notwithstanding Dr. Letheby's evidence, well-established and generally accepted, that cholera is communicable by water, and has, over and over again, been disseminated by the water contaminated by cholera-discharges. It is also a fact that on more than one occasion that dreadful disease has been communicated by Thames-water."

A recent issue of French coin, made from Australian gold, has been found so brittle as to break easily under ordinary use; it has accordingly been recalled. The brittleness is supposed to be due to the presence of a small percentage of antimony and arsenic, both extremely difficult to remove. These substances are said to produce a like effect in all metals or alloys which are subjected to the molecular changes induced by the pressure and heat developed under the action of the dies in the copying-press.

The archives of the Paris Jardin des Plantes contain 6,000 volumes and over 1,500 manuscripts that have hitherto been huddled away as so much lumber. Recently M. Milne-Edwards has arranged for examining, cataloguing, and placing at the disposition of the scientific world this valuable collection. There are several MS. by Buffon, Cuvier, and Daubenton, and a series of pen-and-ink drawings by the last-named naturalist, representing the various types of merinoes; also many albums filled with drawings of plants and flowers.

Dr. Günther shows that the whitebait, a fish highly esteemed by epicures, is nothing but the fry or young of the herring, and this he proves by showing that both fish have the same number of vertebræ and of lateral scales, as also the same arrangement of fins and teeth. This statement is further confirmed by the fact that an adult whitebait in roe has never been found.



BAY OF BAIÆ, NEAR NAPLES, A SCENE OF REMARKABLE TERRESTRIAL CONVULSIONS.

1. *Puzzuoli*, where the relative level of land and sea has changed, twice since the Christian era, from 20 to 30 feet. 2. *Temple of Serapis*, built long before Christ; three columns still standing. 3. *Caligula's Bridge*, 1,800 years old; several piers and arches still standing. 5. *Monte Nuovo*, thrown up by an earthquake (see page 515).